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May 27, 1926

Engineering News-Record

Water-Works Number

Well Water Pumped by Air Lifts

Designing Lake Water-Works Intakes

A 2,000,000-Gallon Elevated Steel Tank

Town of 4,000 Spends $90 per Capita For Water and Sewage

The Country's Largest Pumping Station

What is Doing in the Major Water Supplies

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DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

FRANK C. WIGHT
Editor

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Water Men at Buffalo

AT ITS Buffalo convention two weeks hence the American Water-Works Association has a program of sufficient variety to meet the needs of all classes of members. Embarrassment of riches will be the only cause of disappointment, due not alone to the danger that so many topics distributed over five days will prove wearisome, but also to the physical impossibility of being in two or more places at once—at sectional meetings held simultaneously. As a relief to the strenuous technical program, however, the manufacturers offer plenty of entertainment, carefully planned to be noncompetitive, while the golf committee offers a full schedule. Waterworks men who want to keep up with the developments in their field will find at Buffalo an instructive week. For those who cannot go, and for those who do as well, *Engineering News-Record* offers this week an issue directed toward their specialty.

Lake Water Intakes

IN LOCATING water intakes on the Great Lakes much attention used to be paid to getting beyond the zone of sewage pollution. No mention of sewage pollution is made in the article on lake intakes which appears elsewhere in this issue. Offshore distance and depth of intake are given first place in the article but only as regards turbidity due to wave action. The omission can hardly be due wholly to the assumption that the depth and distance that are sufficient to guard against turbidity are as far as need be gone in these days to guard against sewage pollution, for if that were the case probably it would have been so stated. The explanation seems to be the assumption that water purification—and sewage treatment as well, in some cases—is now relied on for safeguarding lake water supplies from sewage pollution rather than the location of the water intakes.

Size Not All

DANGER of the charge of being misinformed always threatens anyone who applies the superlative to an engineering creation. It seems reasonably safe to use "the world's largest" in mentioning the 300-m.g.d. pumping station at Chicago, the 2-m.g. elevated water tank at Charleston, and the diameter and mileage of riveted wrought iron and steel pipes in the distribution system of the Spring Valley Water Co., San Francisco. In each of these cases, size, although a matter of local pride and general interest, has less significance than other features worthy of consideration. At Chicago, after being duly impressed with the assemblage in a single station of so many large pumps, the engineer finds more interest in the careful and continuing studies made to determine the need for additional pumping capacity, the best location and capacity of each new station and the selection of the most promising type of pumps, boilers and auxiliaries. That tank builders have beaten and presumably stand ready to continue to exceed the previous record capacity of elevated water tanks, is of less moment than the causes that appear to be leading water-works to increase their use of elevated tanks, as they seem to be doing of late. San Francisco's extensive use of thin pipe for large water mains is largely due to local conditions, particularly freight charges; nevertheless, it is worth noting that our cities and water companies have a variety of materials to choose from in this as in other fields, and that engineers outside San Francisco may find it worth-while to study Mr. Pracy's figures of comparative costs of steel and cast-iron pipe.

Bold Cofferdamming

COFFERDAM construction of the cellular sheetpile type, as bold and complex perhaps as any similar operations since those for raising the battleship "Maine," for building the Black Rock ship lock and for unwatering the 46th St. pier area at New York City is described in this issue. The construction was called for in connection with the new water supply of St. Louis which has developed several operations of notable engineering interest. Inside, the St. Louis cofferdam has clear dimensions of something over 100x125 ft. These figures rank small beside the 200x887 ft. of the Black Rock dam and the 170x350 ft. of the Havana Harbor structure but the unsupported height of 45 ft. is greater than either the Havana or Buffalo dams, though 10 to 15 ft. below that of the North River pier. There is an interesting study in design offered by this type of structure, but for the occasion particular mention will be made only of the precision of the construction processes. Anyone who has witnessed the idiosyncracies of behavior possible to a 60-ft. steel sheetpile will grant full praise to the constructor who drove 1,666 of them and varied only four piles from the mathematical calculations of the engineer. The methods are explained in the article. The feature chiefly to be observed is that assembling was kept well ahead—often several cells ahead—of driving and that the pile location was determined by precise templeting.

Licensed Contracting

LICENSING of contractors seems to be growing in favor, though little concerted thought is being put upon it by those most interested. The movement started in North Carolina. For a year contractors there have worked under a license law and express themselves as satisfied of its utility. Experience has disclosed to them, they say, the desirability of certain modifications particularly with respect to a more defi-

nite classification of contractors, or grades of licenses, and these will be sought by amending the law. As written the statute was less general than that which was enacted; there had to be compromise with lawmakers jealous of any infringement of the principle that freemen may not be legislated out of business. But the North Carolina law, even as it is, is held by the local contractors as having been helpful to contracting and beneficial to the building public. A similar law is now in the Legislature of South Carolina and another has been introduced into the New Jersey Assembly. Some contractors everywhere are making inquiries and speculating about licensing. The contracting industry, whether its leaders like it or do not, has to face the prospect of general license legislation, and as was the case in license legislation for engineers, the movement is without concerted direction by the organized groups. Any general trend, therefore, requires for the best interests of contracting to be changed from a succession of individual actions to unified action, for as the issue now stands it is by no means proved that licensing is desirable either for the contractor or the public. Here is the opportunity for the Associated General Contractors. Their managers stand ready to assume the task. It lies with the members to provide the authority and the funds.

Never Ending Thirst

THERE is no end to the demand of our cities for water—more, better, under a more constant if not a higher pressure, extended ever farther to broader areas. New York, just completing its Catskill project at a cost of over two hundred million dollars, should already be making studies for an additional supply ultimately doubling or tripling the 600-m.g.d. flow through the Catskill aqueduct; for a year past its Board of Water Supply has been waiting for the approval of a second deep-pressure tunnel to make still more of the Catskill flow available on the Brooklyn side of the city. Across the continent, Los Angeles, whose marvelous aqueduct was completed only yesterday, as it were, is well advanced in surveys for a vast supply from the Colorado. Between, Chicago is constantly hard pressed to provide tunnels, pumps and mains for getting Lake Michigan water to the growing area and population of the windy city. These are the big cities but they are, for all that, no less typical of the ever continuing and increasing demand for more and better water supplies. Huge as $200,000,000 may look it means no more to the 6,000,000 people of New York City than $2,000,000 to a city of 60,000 or $200,000 to the town of 6,000.

Census estimates show 79 cities of 100,000 or more population on July 1, 1925. Everyone of these has water-supply problems of considerable magnitude. At the 30,000 point the number of cities rises to nearly 300. Beyond this the numbers rapidly increase as smaller and smaller places are taken in until finally we have some 10,000 communities in the United States and Canada which already have some kind of water-works. Thousands more places, minor except in their own eyes, need and are as well able to have works as many of those already having them. So altogether 13,000 to 15,000 cities and villages in the United States and Canada thirst for water or for more and better water. These water-supply needs are so many in number and so immense in total as to afford opportunities for whole armies of engineers, contractors, supply men and financial houses, while in scale and scope there is such a variety as to make chances for all sorts and capacities of men in each class.

Let us see how in time the problem of water supply may change as presented to a single city. Los Angeles, having turned to the Colorado River to supplement—or put in the shade as to magnitude—its present main source, Owens River via the famed Los Angeles Aqueduct, will shift materially both the character and mode of its supply. Instead of a relatively clear water from the snow and ice of the high Sierras, delivered by gravity, it will take water from the turbid Colorado and lift it 1,400 ft. for subsequent gravity flow. This project is not only mammoth in scale—an ultimate supply of 1,500 sec.-ft. or nearly a 1,000 m.g.d.—but also in the clarification problem presented by the turbid Colorado. Little has yet been announced as to the probable solution of this problem, except that the city is already at work on an infiltration canal along the river which may be as much as 15 miles long.

Contrasted with New York's 600-m.g.d gravity supply, by far the largest quantity delivered through a single aqueduct anywhere in the world, we have at Chicago not only the largest total volume of water supplied by pumping in any one city but there is now under construction the world's largest water-works pumping station, with a capacity of 300 m.g.d., or half that of the Catskill gravity aqueduct. On the one hand we marvel at going a hundred miles for the sake of water pure enough to need no treatment as yet except chlorination; on the other, at what nature has done in putting an inexhaustible source of supply at the very doors of one of the largest cities in the world and what man has done in providing a network of huge tunnels and immense pumping engines for its utilization.

If nature was kind in providing or man in taking advantage of the Great Lakes as a doorstep source of water supply it is equally true that nature was unkind in not supplying equal advantages to dispose of wastes without polluting the supply and that man was slow—on the Great Lakes—in coping with the disadvantage. However, with the imminent completion of the Buffalo water filters, all the cities on these lakes except Chicago, Milwaukee and Duluth will have built water filtration plants. Duluth apparently has less need of filters than the other lake cities. Chicago, after reliance on its long lake tunnels and its sewage diversion from the lake southward, is now under virtual orders from the United States authorities to prepare the way for filters. Milwaukee is relying upon its long intake, sewage treatment and chlorination as safeguards against drinking its own sewage.

The problems of water supply are indeed many and various, but they are never static. Just as no city stands still in growth, so is its water supply never fully adequate. Always the future with its demands looms ahead. The water-works engineer, burdened sometimes with routine, overwhelmed with the details of operation and of maintenance, must always keep one lobe of his brain projected forward toward that certain day when new sources must be tapped and growing pollution counteracted. In no other branch of engineering do human needs demand a more instant response.

Railway Labor Relations Readjusted

AN EXPERIMENT in labor relations passes with the signing last week by the President of the bill abolishing the Railway Labor Board and substituting therefor regional adjustment boards representing management and labor. The Railway Labor Board, a part of the famous Transportation Act of 1920, was an attempt to solve railway labor difficulties by governmental mediation, with the railways, labor and the public all equally represented in the mediating body. That body had the power of initiative as well as of appeal from either side in a controversy, but it did not have the power of enforcing its decisions. It was hoped that such power would automatically result from the nature of the board's composition, that it would in effect prove an iron hand in a velvet glove. In many of the minor cases it did so prove, but it was far from effective when a major issue arose.

The new plan was submitted by the railways and their labor acting jointly, and is hopeful in that it represents a conscious effort on the part of this industry to solve its own internal problems. A great hue and cry has been raised in many places, notably among organizations and individuals with strong anti-labor leanings, against the new law. These opponents of the bill point out that the public is not represented in the "Boards of Adjustment" which are to be set up by the railroads and their employees for the adjustment of wages. They claim that with such an arrangement, the railroad management and their employees can "by collusion" raise the rate of wages and pass the cost on to the public in the form of increased freight rates.

Such is not the case. The Interstate Commerce Commission has absolute control over changes in railroad rates. The public is adequately protected by that body, made up in its entirety of men from outside of railroad service. The public does not need to be represented on the boards of adjustment in order to prevent collusion in the matter of increased wages. These boards are set up within the railroad organizations to settle *disputes* over wages and working conditions. No amount of representation by the public on such boards could prevent a raise in wages if the railroad companies and their employees were agreed upon the desirability of such a raise because there would then be no dispute which would necessitate convening the board.

Under the new law if a board of adjustment fails to agree then either party to the dispute may take it to the "Board of Mediation," a permanent board made up of three men from outside the railroad field appointed by the President. If this board cannot effect an agreement, it is required "to use its best efforts to induce the parties to submit their controversy to arbitration" by a board of arbitration to be selected in part by each party to the dispute with a third member selected by mutual agreement or by the board of mediation. If, however, the bodies are unwilling to submit to arbitration, then, provided the dispute is of such a character as to threaten serious interruption of interstate commerce, the President is empowered to appoint an unbiased "Emergency Board"—a board made up of men who are not "pecuniarily or otherwise interested in any organization of employees or any carrier"—to render a decision, which while of course not binding has the force of public opinion behind it.

Surely then, the public is adequately represented in any matters that affect the public welfare. To extend the representation down into the local boards of adjustment would be meddling in affairs which are matters of concern only to the railroad companies and their employees. The Labor Board was not conspicuously successful; its successor now has the chance to show whether the railways have in themselves that self regulatory potentiality that is the only safeguard against dangerously active government control.

Public Water Control

LAST week at the National Electric Light Association meeting Owen D. Young put the case of public ownership of water powers with characteristic clarity and breadth of view. "The control of rivers which require development for several purposes, such as navigation, irrigation and flood control, as well as for power," said the chairman of the board of the General Electric Co., "develops a new kind of question which is wholly unrelated to the old controversy of government vs. private ownership." The control of the water, he argued, is necessary for a number of obviously public purposes, and it is quite plausibly not in the public interest to permit such control to be entirely in private hands. Yet, the production and distribution of power carries into so many of the details of business and has so many ramifications of administration and of development that it presents the best possible case for the argument against public ownership.

The solution would seem to be, in the opinion of Mr. Young, the development of a government agency which shall take control of the waters, shall build the dams, and even if necessary the power houses, but shall cease functioning as an administrative body at that point. This, in effect, is the system adopted in the Province of Quebec which has so many times been cited as a superior method to the full public ownership which has taken control of the administration not only of electric power but of all the politics in the Province of Ontario and which is used so frequently by the doctrinaires in this country as an illustration of what we should do in our states.

Water control is obviously a government function and that control may well be extended to the production of power at the individual site, but when the interconnection of power is required, as it is practically in every development, when distribution lines must be built, when steam power must be fed into water power, and vice versa, when all of the intimate relations of purchase and supply must be controlled, that, according to the philosophy which has made America what it is, is a private function. Mr. Young represents one of the large interests which is supposed to be a violent opponent to any kind of public ownership or control. His recent utterances, and particularly this one at Atlantic City, show that he is leading the way in that industry to the kind of thinking which will be acceptable to that great majority who believe that private initiative is necessary in this country, but who also realize that the power business is so inextricably interwoven with a number of other public uses of water that something more than mere regulation in many cases is demanded.

Factors Considered in Designing Largest Pumping Station

Reasons Given as to the Necessity, Capacity, Type of Unit and Choice of Equipment on the New Western Avenue 300-M.G.D. Installation in Chicago

By Loran D. Gayton
Engineer of Design, Designing Division, Bureau of Engineering, Chicago

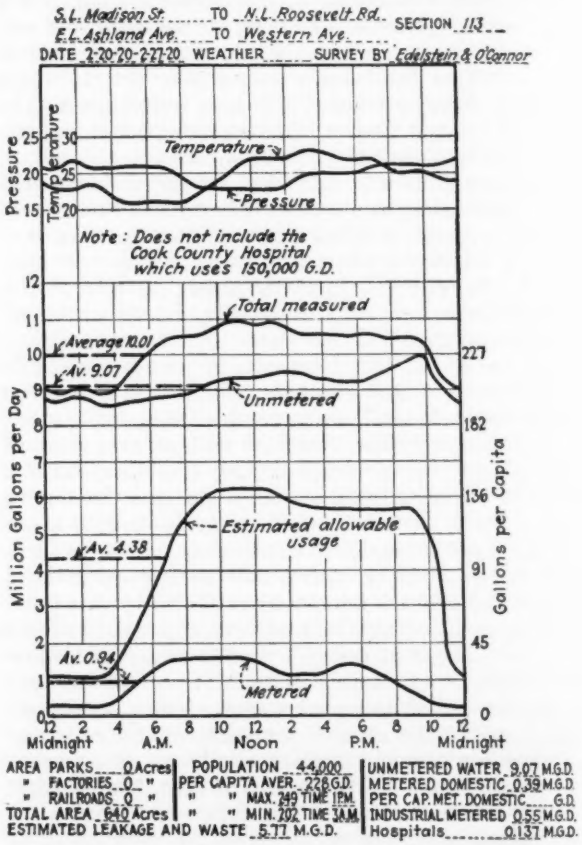
WHEN it becomes necessary to build a new pumping station in Chicago, where to put it, of what capacity, what kind of pumps to use, what kind of prime mover will best fit in with the local power available and what kind of auxiliaries to choose are a few of the questions the designing engineer must answer. Reliability of operation is the factor to which all others must be subordinated, but I believe most engineers will agree that as a rule the most reliable design is also the most economical. This article purports to show the procedure followed by the Bureau of Engineering of Chicago in attempting to arrive at not only the most reliable but also the most economical design.

To illustrate the different steps of determining need, location, tunnel requirements and station equipment, the 300-m.g.d. Western Ave. Station which is now under construction at Forty-ninth St. and Western Ave. is used as an example. Like all the other Chicago stations this one pumps directly into the mains.

Need of the Station—The intelligent design of present and future extensions to any water-supply system requires a thorough knowledge not only of the quantity of water needed but also of the location where the consumption will take place. It is also important that the variations in the demand and the peak loads be ascertained. These factors are affected by the occupation of any area. For instance an industrial district will require different amounts and at different times than a purely residential area. This phase of the work is handled in Chicago by the engineers of the Water Pipe Extension Division of which J. B. Eddy is engineer in charge.

The city is divided into sections having an area of about one square mile each. At certain time intervals each of these square miles is isolated and the quantity of water consumed is measured for several days by means of pitometers. In this way a continuous record of the amount of water consumed in any particular area is obtained. Data on population, character of occupancy, vacant areas, areas of parks and railroads and probable future development are collected for the purpose of determining the ultimate consumption of water in the area; then the water demand for the future is estimated. Two curves are plotted for each section, one showing the actual consumption and the other the estimated future demand.

To get a daily record of the pressure conditions in the entire system, 62 pressure gages are maintained in fire-engine houses and the pumping stations throughout the city. Records from these gages are mailed daily to the assistant engineer of the district, who has pressure curves plotted for each weekly period. The curve for each week is forwarded to the engineer of the Water Pipe Extension Division and thus an accurate record of past and present pressure conditions is always on file. A chart in the city engineer's office, which is changed daily, keeps him posted as to pressure conditions in the entire water-supply system. A gradual dropping off in the pressure in any area is the first indication of the need of a new pumping station. For a time the pressure is kept satisfactory by a manipulation of valves in the system. This procedure reduces



WATER USE SURVEY MAP AND CONSUMPTION CURVES OF TYPICAL SQUARE MILE UNIT, CHICAGO WATER-WORKS

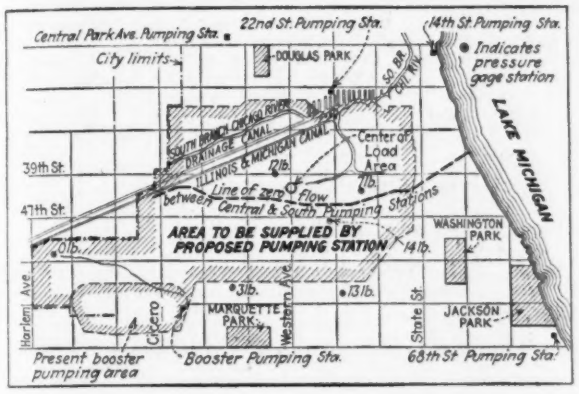
the pressure in a district near the station where it is generally higher than necessary and increases it in outlying districts. Eventually, the manipulation of valves or the addition of larger mains or new equipment in existing stations does no good. The only alternative is then a new station to supply the low-pressure area.

Location of the Station—To keep the cost of the distribution system at a minimum and also to operate the station under as low a discharge head as practicable a careful study of the station-load area must be made. The station is located as near as possible to the center of that area.

Chicago has ten major pumping stations and the entire distribution system is a unit; that is, each station system is connected to all the others. There is therefore a line of no flow between the stations. This line fluctuates back and forth as the demands upon the individual stations vary. The line of zero flow between the central district and the south district pumping sta-

tions falls about on Forty-third St. across the entire city. The proposed station should be near this line of zero flow. If a line is drawn from north to south to divide the proposed station area into equal loads (except the Stock Yards) it falls near Western Ave. If a line is drawn from east to west to divide equally the load requirements, it falls near Forty-third St., so that Forty-third and Western Ave. is the load center of the proposed area and the station should be placed as near this point as possible.

The Union Stock Yards and Packing Town are located one mile east of the proposed station, a location which will make it possible to isolate this section, giving better service and eliminating the Stock Yards, with their



LOCATION OF CENTER OF WATER PUMPING LOAD AREA DETERMINED FROM UNIT SURVEYS AND PRESSURE GAGE STATIONS

great peak-load demand, from the surrounding sections. The station should be as near as possible to the Stock Yards and at the same time as near as possible to the center of load for the surrounding area. The section of the city north and west of the Stock Yards is a rapidly developing industrial section requiring that large additions be made to the water system to meet the increasing demand for service. The station location as finally selected is near this industrial area and will meet the demand giving proper pressure with small loss from friction and ample fire protection in what is destined to be a high-value district. The section southward and westward is made up largely of homes in which there exists a great shortage of water. The proposed station will relieve this low-pressure condition.

Capacity and Head—The required capacity of the station is based upon the population to be served and the per capita consumption of water. Under the present conditions, with only 10 per cent of the services metered, a maximum per capita consumption of 350 gal. per day was assumed. When the area is built up this station will serve a population of about 600,000, requiring a capacity of about 217 m.g.d.

Before deciding upon the discharge head against which the station must operate, the distribution system must be designed. A pressure of 25 lb. in the mains at the point most distant from the station is assumed as well as a maximum velocity of 5 ft. per second in the mains. In most localities in Chicago the depth of the sewers below grade prohibits the use of water pipe larger than 48 in. Weston's tables are used in figuring friction losses. Starting at the most distant connection from the station and allowing 25 lb. pressure at that point we work back toward the station. Differences in elevation are taken into consideration. In the case of the Western Ave. pumping station it was found that a discharge head of 107 ft. was necessary at ground level at the station.

Tunnel System—The next step is the design of the supply system consisting of the intake-crib tunnels. Where one tunnel or section of tunnel is to supply one or more stations, and the cost of pumping per foot of head and the cost of different-size tunnels are known, it is possible to derive an equation between the cost of pumping and the fixed charges and maintenance cost of the tunnel, and determine the most economical size of tunnel. Variations in the depth of the pump pit as affected by the tunnel size must be considered. In most cases the tunnel is made larger than the economical size in order that it may take care of an estimated future load. So far as the Western Ave. station was concerned the necessary crib and the lake tunnel were already built. It was only necessary to design an extension of the South-West tunnel from Seventy-third and State St., west in Seventy-third St. to Western Ave. and north in Western Ave. to Forty-ninth St., a distance of about six miles.

The Western Ave. tunnel, which will supply the Western Ave. station, also supplies the Roseland and partially the Sixty-eighth St. station. It was therefore quite essential to know how the flow of water would be distributed when all three of these stations were operating at once. To ascertain the maximum amount of water that could be taken from the tunnel at Seventy-third and State Sts. without causing the levels of the suction shafts at the Sixty-eighth St. station and especially the wet wall of Roseland station to be lowered beyond a safe operating depth, the hydraulic gradient was located by photo-recorder instruments devised from equipment used in the pitometer survey division.

Values obtained for n in Kutter's formula were surprisingly high and some doubt as to their accuracy arose, but subsequent checks proved that they were correct. The average values of n were as follows: In the 14-ft. section, Dunne crib to Yates Ave., $n = 0.019$; in the 12-ft. section Yates Ave. to State St., $n = 0.017$; and in the 9-ft. section State St. to Roseland pumping station, $n = 0.016$. In all past designs n has been taken at 0.015. This work was done under the direction of Paul Lippert, engineer of pumping station efficiency.

Experience has shown that a water velocity of about 3 to 4 ft. per second in tunnels of this length gives an economical section. Assuming this velocity and the maximum capacity of the new station as 217 m.g.d. we arrive at a 12-ft. Chicago-section tunnel.

The maximum demand from the system by the Sixty-eighth St. station will be 74 m.g.d., by the Roseland station 100 m.g.d. and by the Western Ave. station 217 m.g.d. Using these quantities of water and the coefficient of roughness for the different sections as found by the survey and solving Chezy's formula for the slope, it was found that there would be a loss of head of 20 ft. between the Edward F. Dunne crib and the suction well of the Western Ave. station. Since the lake level may drop as low as El. —2 the water in the station suction tunnel may be as low as El. —22, and as the pumps may never be compelled to operate under a greater suction lift than 15 ft. they were placed at

El. —11. With the pumps at this elevation and the water in the suction tunnel at El. —22, there can be a friction loss in the pump suction of 4 ft. and still have the total suction lift not greater than 15 ft.

Design of Station—In designing a pumping station and its equipment the engineer finds the greatest opportunity for the use of his technical knowledge and ingenuity. He must have a broad and also a detailed knowledge of all modern power-plant equipment, its efficiency, its limitations and its cost. He must also have a thorough knowledge of structural engineering, because the cost of his buildings, foundations, etc., will affect the selection of his equipment.

Having worked out a load curve for a maximum day for the entire station, pumping units of the proper capacity must be selected. These units must be of such a size that for the greater part of the time they will be operating at or near their most efficient point yet be of such a flexibility that they may carry an under or overload without inconvenience. They must also be of such a size that there is always safe reserve capacity and yet too much money must not be tied up in reserve equipment. The following types of equipment were studied and compared:

Triple-Expansion Pumping Engines—These engines are by far the most economical in steam consumption (205 million duty, at 200 lb. gage pressure and 100 deg. F. superheat) of any steam pumping unit of the present day. Therefore their coal consumption is much lower than any other steam unit and the boiler plant can be made somewhat smaller. On the other hand the maximum size for this type of unit is 50 m.g.d., so that it would require six triples to do the work of four turbo-centrifugals and the original cost of the triples is three times that of the turbo-centrifugals. The buildings for the triples cost more than those for the turbo-centrifugals, the labor cost is higher, there is trouble in using the condensate due to oil and it is more difficult to follow the load curve than with a turbo-centrifugal. Therefore the cost of operation of the triple-expansion station for the Western Ave. station would be about 14 per cent higher than that of a turbo-centrifugal station.

Steam-Turbine Geared Centrifugals—Fuel cost for the turbo-centrifugal station is considerably more than for a triple-expansion station, but the buildings cost less, the labor cost is less and the cost of the equipment about one-third as much; therefore the total cost is 14 per cent lower than of the triple-expansion station. The condensate can be reclaimed, as there is no oil in the steam, and it is easy to follow the load curve with this type of unit.

Diesel Oil Engines—The original cost of this type of equipment is so high that the cost of the entire equipment is about $500,000 more than a steam-turbine station. The fuel cost is about the same as the steam-turbine plant, the buildings cost and the labor cost are both less. In the final analysis the cost of operation of the Diesel station is about the same as the steam-turbine station. There are mechanical difficulties in the design of a Diesel pumping station which would tend to disbar it in such a station as Western Ave., regardless of any consideration of operating costs. Engines of the required horsepower operate at about 120 r.p.m. To develop 150-ft. head at 120 r.p.m. would require four stages of centrifugal pumps and the impellers of these pumps would be about 11 ft. in diameter. Pumps of this size would be an experiment and their efficiency would be problematical. The installation of gears would still further increase the first cost.

COMPARATIVE ESTIMATED COSTS OF COMPLETE STATION

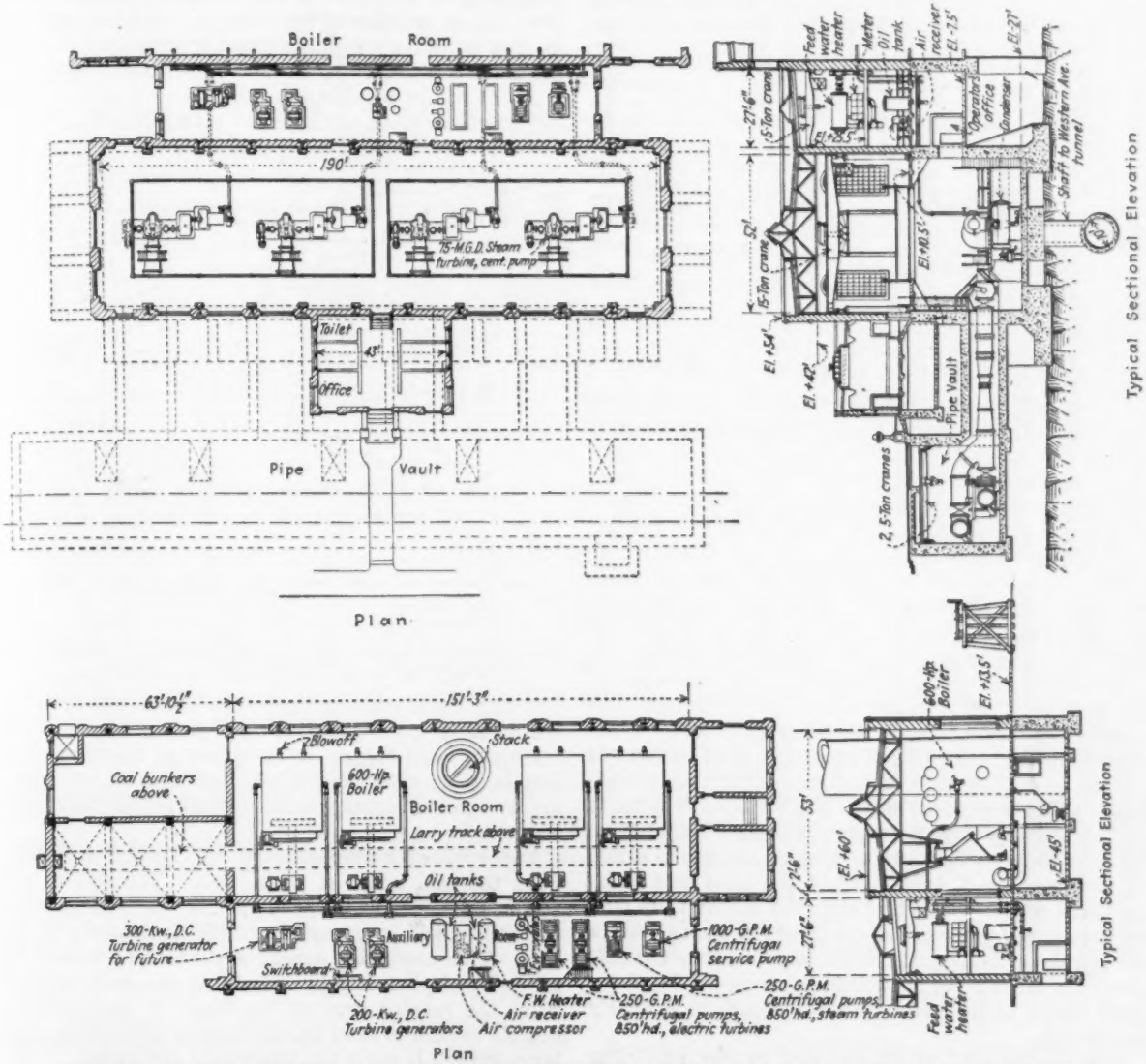
Costs based on 300 million gallons per day for 300 days per year (which is equal to 90,000 million gallons per year) against a total head of 150 feet.

	Type of Prime Mover	Steam Turbine: Steam Press., 300 lb. Superheat, 200 deg. F. Abs. Back Pres., 1 Lb.	Triple Expansion Eng.: Steam Press., 200 lb. Superheat, 100 deg. F. Abs. Back Press., 2 Lb.	Diesel Oil Engine 6 Cylinder, 2 Cycle	Electric Motor 2,300 Volts	Electric Motor 12,000 Volts
General Data	Type of pump	Centrifugal single-stage	Plunger pump	Centrifugal 4-stage	Centrifugal single-stage	Centrifugal single-stage
	Capacity of pump, million gallons daily	60	50	60	60	60
	Water horsepower of pump	1,590	1,315	1,590	1,590	1,590
	Engine horsepower	1,900 brake	1,390 Indicated	1,900 brake	1,900 brake	1,900 brake
	Mechanical efficiency of unit, per cent	Pump, 83½ 94½		Pump, 83½	Pump, 83½ Motor, 94	Pump, 83½ Motor, 94
	Actual thermal efficiency of unit, per cent	18	21.8	23.7	.....	.....
	Steam or oil consumption, lb. per water horsepower hour	11.45	9.66	0.565	.....	.....
	Steam or oil consumption, lb. per engine horsepower hour	9.55 per brake hp.	9.15 per i. hp.	0.473 per brake hp.	.....	.....
	Electric power consumption, kw.-hr. per million ft.-gal.	.....	.....	.....	4.75	4.655
	Boiler horsepower required	4,060 5 units in operation	3,200 6 units in operation	.....	.....	.....
	Duty-million ft.-lb. of work per 1,000 lb. steam	173	205	.....	.....	.....
	Duty-million ft.-lb. of work per million B.t.u.	130	152.8	184	.....	.....
	Fuel or power for 300 days	61,200 tons of coal 5 units in operation	48,240 tons of coal 6 units in operation	4,752,000 gal. fuel oil 5 units in operation	64,125,000 kw.-hr. 5 units in operation	62,842,500 kw.-hr. 5 units in operation
Original Investment	Cost of land	$52,072	$58,748	$32,550	$23,400	$20,900
	Cost of buildings	933,350	1,154,250	656,800	455,000	420,000
	Cost of equipment	1,201,400	2,423,858	1,716,495	352,500	342,900
	Miscellaneous	18,000	20,000	66,000 fuel oil tank	20,000	20,000
	Total investment	$2,204,822	$3,656,856	$2,471,845	$850,000	$803,800
Operating Costs per Year	Cost of labor	$63,495	$89,437	$30,000	$25,680	$25,680
	Cost of fuel—Coal $4 per ton—oil $0.05 per gal.	244,800	193,944	237,600	.....	.....
	Cost of power $0.0064 per kw.-hr.	.....	.....	.....	413,904	408,132
	Cost of oil, waste, etc.	3,000	15,300	20,000	5,000	4,000
	Repairs and maintenance	22,624	40,616	13,700	5,280	5,144
	Interest on investment and depreciation	136,600	201,700	179,385	69,200	65,735
	Total operating cost	$470,519	$537,997	$480,685	$519,064	$508,691
Unit Costs Per Mill'n Gal.	Labor	$0.71	$1.00	$0.33	$0.285	$0.285
	Fuel or power	2.72	2.12	2.64	4.60	4.535
	Oil, waste, etc.	0.03	0.17	0.22	0.056	0.044
	Repairs and maintenance	0.25	0.45	0.15	0.06	0.057
	Interest on investment and depreciation	1.52	2.24	2.00	0.77	0.73
	Total cost of pumping	$5.23	$5.98	$5.34	$5.77	$5.65
	Total cost of pumping one million gallons one foot high	$0.0349	$0.04	$0.0356	$0.0385	$0.0377

Motor-Driven Centrifugal Pumps—This type of station requires less land, less building space, less equipment and less labor than any other. The entire original investment is about 40 per cent of a steam-turbine station. The cost of the electric energy is the controlling factor, and this brings the total operating cost of the electric station (with constant-speed induction motors) about 10 per cent above the steam-turbine station.

In this connection it is safe to say that for large pumping stations, of 200 m.g.d. and over, and operating against comparatively high heads, the steam-turbine geared-centrifugal pump will show the lowest overall operating cost, when all the factors entering into this cost are considered.

After deciding upon the use of steam turbines for the Western Ave. Station the matter of steam pressure and temperature was discussed with various builders of this type of equipment. Impulse turbine builders agreed that 300-lb.-gage pressure and a total temperature of 621 deg. F. would require nothing special in the way of material or design and would result in highly efficient operation. The builders of the reaction type of turbine recommended a somewhat lower pressure with the same total temperature and would guarantee the same economy as the impulse type. A gage pressure of 300 lb. and a total temperature of 621 deg. F. at the turbine throttle was selected as a steam condition which was conservative and yet would allow the builders to design a unit of high economy.



THE 300-M. G. D. WESTERN AVENUE PUMPING STATION, LARGEST TOTAL CAPACITY STATION YET BUILT

Main Pumping Units—A study of the station load curve showed that three pumps having a capacity range of from 50 to 75 m.g.d. and a total head range of from 107 to 150 ft. would give ideal operating conditions. A fourth unit was added for reserve. There will never be more than three or less than two pumps operating at once. As these units have a very high overload capacity two of them can carry the average load if for any reason two pumps should be out of commission. Certain details of the equipment as called for in the specifications, with some omissions, are:

Turbine—The steam turbine shall be of the horizontal-shaft, multi-stage type. The revolutions per minute of the turbine shall not exceed 5,500 at full rated capacity of the pump and the peripheral speed in feet per second at the tip of the moving buckets shall not exceed 900 ft. per second under any condition of operation.

The turbine shall be built for steam conditions of 300-lb. gage and 200 deg. superheat, measured at turbine inlet, and approximately 28½ in. vacuum referred to a 30-in. barometer at the turbine exhaust nozzle. Sufficient nozzle area shall be provided to enable the turbine to drive the pump at its full rated capacity with a steam pressure of 250 lb. at the turbine inlet and 150 deg. superheat and with such a vacuum as may be produced by the condensing equipment when the temperature of the water entering the condenser is 75 deg. F. Provision shall be made to bleed out from 0 to 4,000 lb. of steam per hour at 2-lb. gage pressure.

Gears—The gears shall be of the double-helical type. The tooth pressure per lineal inch width of face, measured parallel to the axis of pinion and gear shaft (not along the working surface of the teeth) must not exceed 400 lb. when the unit is operating under maximum load conditions. The pitch-line speed of the gears shall not exceed 7,500 ft. per minute under any conditions of operation.

Pumps—Both the main and the circulating pump shall be of the single-stage, double-suction, horizontally-split-casing, single-enclosed-type impeller construction, with suction vertically downward and discharge horizontal. The speed of the pumps shall not exceed 600 r.p.m. under maximum operating conditions.

Condensers—The surface condensers shall have not less than 1 sq.ft. of tube surface for each 5 lb. of steam consumed per hour by the main unit and all its auxiliaries.

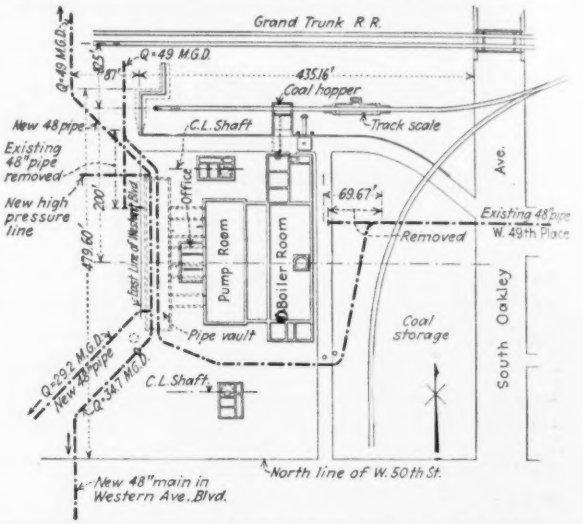
The pumping equipment selected for this station consisted of four compound turbine-geared-centrifugal pumps. Four bids were received, three on single-barrel turbines and one on compound turbines. Although the latter type was highest in first cost, it was lowest in steam consumption and showed a saving of $84,000 in the cost of the necessary building. When evaluated as to operating cost this proposal was the lowest received. The compound units have a guaranteed water rate of 9.5 lb. per water hp.-hr. or a duty of 208,000,000 ft.-lb. per 1,000 lb. of steam at the most efficient point.

Steam Generating Equipment—After the main pumping equipment had been selected and the steam requirements calculated, studies were made of different types of steam boilers, combustion apparatus, etc. Mechanical stokers, powdered coal and oil-fired boilers were considered. Stokers were adopted. An investigation made by the writer a few years ago indicated that for an installation requiring about 4,000 b.hp. steam could be generated by stokers at about the same cost as by powdered coal. Also at that time the danger from dust explosions was considered too great a hazard for a municipal water-pumping plant. More recently the unit type of powdered-coal apparatus has been developed for small plants to the point where it should be seriously considered.

The relative cost of oil and coal in any particular locality will decide which of these fuels should be used. In a city where oil is low in price and coal high the former is generally the more economical, but in Chicago, where bituminous screenings cost $2.90 a ton, rail delivery, and oil costs 5c. per gallon, and taking into consideration the relative boiler efficiencies, the cost of steam from fuel oil is approximately double the cost of steam from coal. The price of oil fluctuates whereas the price of coal has been comparatively uniform for many years.

Boilers—A tabulation of the steam loads for each hour of the day gives a clear insight into the demands upon the boiler plant. If the highest economy is to be attained the boilers must operate at or near their most efficient point for the greater part of the time. If economy of operation is being sought it is well to limit the boiler range between 100 and 200 per cent of rating. The highest efficiency generally is between 125 and 150 per cent of rating.

A study made before deciding upon the size and number of boilers for the Western Ave Pumping Station showed that if 600-hp. boilers were selected the peak load could be carried on three boilers, with one and two units on the line for the remaining hours of the day. In an emergency the peak load could be carried on two boilers by running them at slightly over 200 per cent of rating. If smaller boilers were installed, it would not be possible to carry the peak load on two boilers at the assumed maximum rating of 200 per cent



HOW THE SIX DISCHARGE MAINS GET AWAY FROM THE WESTERN AVE. WATER PUMPING STATION

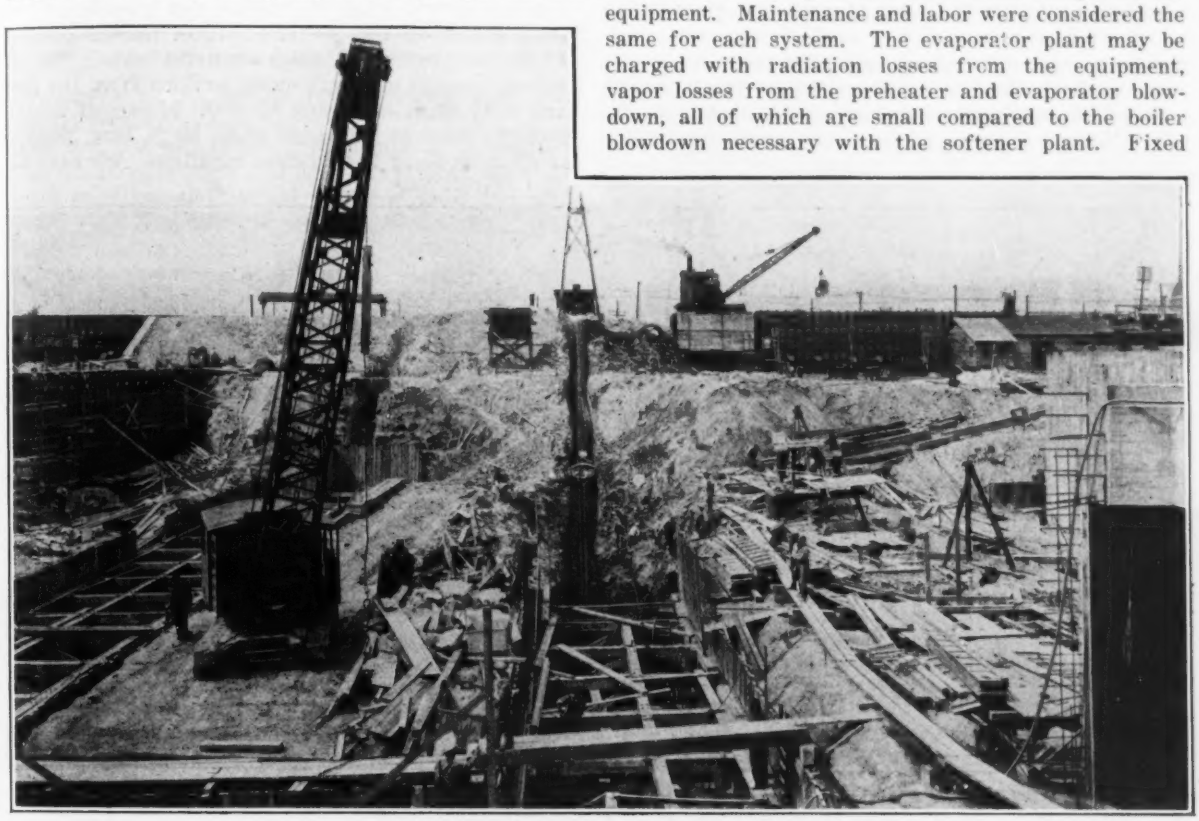
and the installation of larger boilers would increase the number of banked hours, increase the required investment and reduce the flexibility of the plant. By installing four 600-hp. boilers, high average efficiency, proper reserve capacity and a flexible boiler plant were secured.

The type of stoker selected will depend primarily upon the coal which is to be used. The size of the stoker, fans, etc., will depend upon the ratings at which the boilers will be operated and the fluctuations in the load. This equipment consumes power and it must be so designed that it will operate at the most efficient point the greater part of the time. It must also be flexible enough to meet the fluctuating demands and yet large enough to carry the emergency overloads.

Boiler Room Auxiliaries—If the highest efficiency and therefore the greatest economy of operation is to be secured the boiler-room auxiliaries and their relation to the main equipment must be carefully studied. Investigations made by the writer in the past indicate that when the average boiler rating is not above 150 per cent it is not economical to install economizers, but that an increase of boiler economy can be shown by the installation of air preheaters of the Jungstrom revolving type.

The desire for a continuous high boiler efficiency led to the use of an evaporator plant for distilling all make-up water to be supplied to the boilers. The small amount of make-up, 2 per cent, required in the station allows the use of a small evaporator, which justifies it from an investment standpoint. Aside from the

evaporator plant and the very high pressure required from the boiler-feed pumps, the feed-water system is not unusual. The boiler-feed pumps are small-capacity centrifugals pumping against an extremely high head. There are three pumps in all, one driven by a steam turbine and the others by direct-current motors supplied by the station generators. To pump against the total head of over 800 ft., the motor-driven pumps will require eight stages, arranged as two four-stage pumps in series with the motor placed between the two pumps. Each unit will have a capacity of 200 gal. per minute which is sufficient for the entire boiler requirement. The discharge from the pumps passes through the vapor condenser where it picks up a few degrees of temperature and passes on into a loop header feeding the boilers.



PIT EXCAVATION FOR 300-M. G. D. STATION

Gasoline crane at left, handling material and excavation, is standing on material to be excavated as soon as walls are built down to grade, 50 ft. below the surface. The 1¼-yd. drag scraper, operated by hoisting engine beyond the bank, was used to remove excavation from walls. Swelling clay required heavy bracing. Steam shovel in background on coal hopper handles muck from tunnel shaft, also concrete aggregate from cars to bins.

Two tanks for the storage of the distilled water are placed in the basement of the auxiliary room, with a total capacity to fill an empty boiler without interfering with the feed process to the other boilers. One of these tanks is floated on the main condensate line continually. It is kept filled from that source rather than attempt to store the hot returns from the evaporators. The contents of this tank are automatically pumped to the feed-water heater at times of low water.

Water softeners to treat the make-up water were considered. The softener plant would consist of two softener tanks with salt pots, and a filter placed in the line preceding the softeners. The first cost of this equipment would be about one-third the cost of the evaporator plant. It is effective in preventing the formation of boiler scale, requires little space and attention and has proved satisfactory in many instances. Boiler blowdown would be continued as in the present pumping stations, where one gage on the boilers is blown down at the beginning of each 8-hour shift. This is an expense that can be charged against the softening system, as the boiler blowdown will be practically eliminated by use of the evaporators. The other annual charges that can be placed against the softener system are salt for regeneration and fixed charges on the equipment. Maintenance and labor were considered the same for each system. The evaporator plant may be charged with radiation losses from the equipment, vapor losses from the preheater and evaporator blowdown, all of which are small compared to the boiler blowdown necessary with the softener plant. Fixed charges were figured at the same per cent as with the softener system. The result of these calculations showed a net annual saving of about $500 for the evaporator plant over the softener. This amounted to a net earning of 12.8 per cent on the added investment of $4,000 to purchase the evaporator plant.

The project is about 60 per cent completed. Excavation and substructure were done and the steel superstructure is being put up by force account, the steel having been fabricated and delivered by the American Bridge Co. The DeLaval Steam Turbine Co. will supply the pumping units. Edge Moor boilers and Taylor underfeed stokers will be used.

All design and construction in the Bureau of Engineering, under which the Western Ave. pumping station is being designed and built, is under the general supervision of John Ericson, city engineer, with the writer in charge of design and J. J. Versluis, engineer in charge of construction.

Experience with Riveted Pipe in San Francisco Water-Works

Length of Service, Cost and Advantages Favorable Compared with Cast-Iron Pipe in City Distribution System

By George W. Pracy
Superintendent, City Distribution Department, Spring Valley Water Co., San Francisco, Calif.

In the early days of California, when hydraulic mining was in full swing, some ingenious miner originated or adopted the idea of riveting plates into cylinders and joining them to form a long line of pipe. In those days all hauling was done by teams and the cost of transporting cast-iron pipe was prohibitive. The late Herman Schussler, who came to California and entered the employ of the Spring Valley Water Co. in 1864, developed the idea until by 1875 he had a considerable mileage of riveted pipe in use. The first of these lines, from Lake Pilarcitos into the city, was finished in 1867. It gave continuous service until 1906, when the earthquake destroyed most of it. The last portion of the line was removed in 1920 after a useful life of 53 years. In fact, its life for other purposes was not yet over, for the portion removed was in such good shape that it was purchased by a second-hand pipe and machinery dealer and resold by him for various uses. Mr. Schussler evidently had some trouble with his first line due to stressing the iron beyond the elastic limit for he had to take up most of it and relay it under a lesser head. Of his second line, the San Andres pipe line, he says in a report made in 1876, "The San Andres line is 30 in. in diameter and 12 miles in length. I subjected the No. 9 iron to 13,100 lb. and the No. 11 iron to 11,400 lb. strain per sq.in., this being from 11 to 20 per cent inside the elasticity limit." This line was laid in 1870 and a great part of it is still in use.

Prior to 1907, all the riveted lines laid, except the submarine pipes, were made of the best grade laminated wrought iron. Since 1907 the lines have been made of steel. The submarine pipes, two 16-in. laid in 1888 and two 22-in. laid in 1901, were made of ⅜-in. steel tubing, first galvanized and then dipped and riveted to cast-iron ball-and-socket joints.

In the development of the city distributing system both riveted sheet metal and cast-iron pipe were used in sizes larger than 16-in. diameter. Pipe 16 in. in diameter and less was all cast-iron. Table I gives the principal data regarding the riveted pipe in use for twenty-five years or more.

From an operating viewpoint, these riveted pipes have been entirely satisfactory. During the past sixteen years, I cannot recall having had any trouble with the lines except in two sections within limited districts affected by electrolysis which are noted below. We have several times had to cut small sections from the lines and relay them on account of sewer construction. The sections removed have been about 50 ft. long, the pipe in all cases being in first-class condition. We have also cut into the lines for new connections and have found the iron in perfect shape. Of the two lines with which we have electrolytic trouble, both passed directly in front of a substation. About 3,000 ft. of 37½-in. main thus affected was relaid in 1913, having then been in use 26 years. The 30-in. line was replaced in part in 1919, after being in the ground 49 years. The lines

LAYING 24-In. WATER MAIN, CORBETT ROAD, SPRING VALLEY WATER COMPANY, SAN FRANCISCO

TABLE I—RIVETED WROUGHT-IRON PIPE IN SPRING VALLEY WATER CO. DISTRIBUTING SYSTEM

Confined to pipe 25 years or more old

Diameter, In.	Gage of Plates, No.	Thickness of Plates, In.	Length, Ft.	Soil	Age in 1925, Years
22	9	3/16	2,105	Hard clay	54
22	9	3/16	12,226	Sand and clay	50
22	7	1/4	10,546	Sand, clay, rock	43
30	3	1/4	3,480	Sand	43
33	3	1/4	2,409	Sand	41
30	3	1/4	4,513	Sand	40
37½	3	1/4	1,818	Sand and clay	40
37½	3	1/4	5,577	Sand and clay	40
37½	3	1/4	1,501	Clay	40
44	3	1/4	4,878	Sandy clay, clay and rock	36
30	3	1/4	4,090	Sand and sandy clay	30
36	7	1/4	420	Sandy clay	25
Total			53,563		

Segregated according to soil: Sand, 27,700 ft.; sandy clay, 11,342; hard clay, 11,388; rock, 3,133 ft.

TABLE II—COMPARATIVE FIRST COSTS OF CAST-IRON AND STEEL WATER MAINS AT SAN FRANCISCO

All pipe laid under bituminous pavement.

Size, inches	16	24	30
Cast iron	$6.07	$9.95	$13.70
Riveted steel	4.71	7.28	8.20
Difference	1.36	2.67	5.50
Years for difference in cost compounded annually at per cent to equal first cost of riveted pipe	26	21	9

The 16-in. pipe was made from No. 10 plates, the 24-lb. and 30-in. from plates $\frac{1}{4}$ in. thick. The pipe was double dipped and then wrapped with a special roofing felt. All field joints were welded, shop joints riveted. Class B pipe with cement joints was taken in the estimate for the cast-iron pipe. These lines were laid in built-up but not highly congested districts. In the latter the labor cost would be higher, which would be in favor of the cast-iron pipe. In all cases, detailed estimates would have to be made and the job studied from every angle before a decision could be reached.

were bonded to the electric return system and have given no further trouble.

The economic side of this type of pipe is interesting. Table II gives a weighted cost of various sizes of riveted steel lines laid in the past few years and also the estimated cost of a cast-iron pipe of the same sizes and same conditions. It must be remembered that these costs are for San Francisco. They may or may not hold true for other parts of the country.

One argument made for cast-iron pipe is that it has a salvage value practically equal to new pipe. With us this is essentially true. Quite recently we took out a 6-in. line that had been in the ground for fifty-two years. After cleaning, it was as good as new and was relaid for another fifty years or more of service. But even this, in large sizes, is not enough to compensate for the lower first cost of riveted pipe as shown by the comparison made in Table II for 30-in. pipe.

Riveted pipe also has a considerable salvage value depending of course upon the length of time it has been in the ground and upon the type of soil in which it was laid. A good portion of our pipe has been relaid and some has been relaid twice. We are now relaying some 36-in. pipe which was originally laid in 1888 and removed in 1925. The cost of cleaning and redipping this line was much less than new pipe, the reclaimed pipe being practically equal to new.

The most important element in prolonging the life of a thin metal pipe is the dip, particularly there must be assurance that the pipe is placed in the ditch with the dip intact. Early in its history, the Spring Valley Water Co. developed a dip made by refining a natural asphalt mined near Santa Barbara, Calif. This dip has given very good service. Lately several of our smaller jobs have been dipped in the ordinary oil asphalt. Lately, also, all pipe has been wrapped with a prepared paper almost identical with roofing felt. This method gives a much thicker coating of asphalt with the additional advantage that the paper prevents the dip from chipping during the handling from the kettles to the ditch.

With a few exceptions, these large, thin metal pipes are not tapped for ordinary house services, but all of them are tapped at street crossings for ties to the distributing system. When the pipe is dry, these connections are made by riveting or welding on outlets as would be done in a boiler shop. If it is necessary to make a tap under pressure, the outlet is fastened to a steel sleeve which is placed around the pipe and the usual lead joint made. The tap is then made with any tapping machine.

The company has had the same favorable experience with its lines outside of the city as with those within the city. The Crystal Springs line, 44 in. in diameter and 18 miles long, made of No. 6 and No. 7 wrought-iron plates, was laid in 1885 and has given continuous service for forty years and is still in good condition. The Alameda pipe line, 36 in. in diameter and 20 miles long, laid in 1887 and 1888 of No. 7 and No. 9 wrought-iron plates, is in good shape after thirty-eight years of use except for about 2 miles laid through the swamp lands along the bay shore. These two miles will have to be replaced within the next two years. Of the force main from Belmont pumps, 34,000 ft. is 36 in. in diameter of No. 9 iron laid in 1888 and 17,000 ft. is 55 in. in diameter of $\frac{3}{8}$-in. iron laid in 1903. The 54-in. pipe was laid on account of needed increased capacity. One mile of the original 36-in. pipe was replaced this year.

LAYING 36-IN. STEEL WATER MAIN THROUGH BUILT-UP SECTION OF SAN FRANCISCO

TABLE III—RELATIVE COST OF LARGE CAST-IRON AND RIVETED STEEL WATER MAINS AFTER 40 YEARS

Assumptions: Diameter, 30 in.; length, 10,000 ft.; pressure, 86 lb.; Class B for cast-iron or $\frac{1}{4}$-in. plates for steel; cast-iron pipe removed, cleaned and sold at original cost price, but steel pipe abandoned after 40 years.

	Cast Iron	Riveted Steel
Original cost	$137,000	$82,000
6 per cent interest per year for 40 years	328,800	196,800
Cost of removing and cleaning	43,000	.....
Total expenditures	$508,800	$278,800
Salvage value of cast-iron pipe at original cost of pipe $9.00 per foot	90,000	.....
Net cost	$418,800	$278,800

TABLE IV—VALUE OF "C" FOR RIVETED WROUGHT IRON PIPES OF SPRING VALLEY WATER CO.

Values given for both Williams & Hazen and Chezy formulas

Name of Line	Size, In.	Age of Pipe When Tested, Yr.	Value of C—W & H	Value of C—Chezy
Alameda, from Niles to Belmont	36	24	107.5	104.8
Belmont to Burlingame	36	24	123.0	122.3
Burlingame to Millbrae	54	9	109.0	106.5
Crystal Springs, Millbrae to Sierra Point	44	27	97.9	96.8
Crystal Springs, Sierra Point to University Mound Reservoir	44	27	89.1	88.5
San Andres, San Andreas to Baden	44	14	113.5	109.0
Baden to College Hill Reservoir	30	42	110.0	103.6
Baden-Merced, Baden to Merced	30	5	114.0	107.0
Pilarcitos, Daly Hill to Lake Honda	30	47	91.5	84.0

It was laid in clay soil along the edge of San Francisco Bay. In the San Andres line, we have 29,000 ft. of 44-in. made of ¼-in. iron plates laid in 1898. The remainder of the San Andres line is about 40,000 ft. of 30-in. pipe of No. 12 iron plates, laid in 1870, except for about 5,000 ft. replaced at various times, principally due to electrolytic trouble. In this section our experience has been that nearly all deterioration is on the outside due to surrounding soil.

After considerable experience in laying thin metal pipe lines from 16 to 44 in. in diameter and maintaining such lines that have been in the ground from one to fifty-four years, it is my opinion that in most cases they should be selected in preference to cast-iron pipe. Either as gravity lines or force mains they give entire satisfaction. Under most conditions they are economical in first cost and in ultimate cost. Care must be taken to see that they are not used under unfavorable conditions and also that they are properly designed and carefully laid.

Well-Water Development with Air Lifts at Lansing, Mich.

Comprehensive Survey Discarded Shallow Gravel Wells and Filtered River Water for Deep Wells with Natural Purity

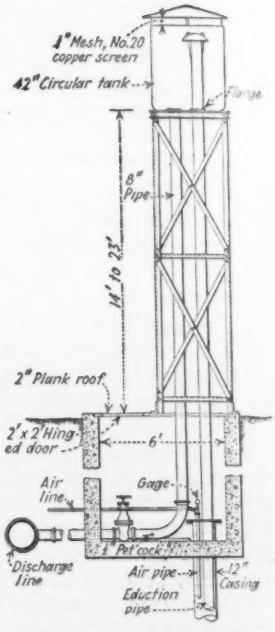
By L. R. Howson
Of Alvord, Burdick & Howson, Consulting Engineers, Chicago

WITHIN the past few months Lansing, Mich., has installed one of the most extensive air-lift pumping plants in the country. Inasmuch as the city has pumped its wells successively by direct suction, deep-well electric turbines and now by air-lift, the Lansing situation furnishes an interesting example of the progressive development of a well supply and the factors bearing upon methods of pumping.

History—The original water-works was built in 1885. The supply was drawn from an open brick well, sunk in sand at the site of the present Cedar St. pumping station. Soon after 1890 the brick suction well was abandoned and succeeded by twelve shallow wells in the gravel approximately 50 ft. in depth. About 1895 twelve tubular wells were sunk in the same vicinity to a depth of 150 ft. These wells were cased to the rock line and extended 100 ft. into the rock. From 1904 to 1909 a policy of building outlying stations at various points on the distribution system was followed, the thought being that the draft on the underground strata could be distributed and that by operating electrically and pumping directly to the mains the additional cost of operating multiple stations would be less than the fixed charges on the savings in distribution system costs effected by pumping to the mains at widely separated points. In accordance with this policy the Townsend St. station was constructed with five wells, Sycamore St. station with five wells and the Pennsylvania Ave. station with 19 wells. All of the pumping at these stations was by direct suction. In 1914 the Logan St. well was drilled, this being a 20-in. well pumped by an electric-driven deep-well turbine pump. In 1917 a well of this type and similarly equipped was drilled at the Cedar St. station and subsequently a second 20-ft. well was drilled at the Cedar St. location. Two of the existing 12-ft. wells were equipped with deep-well turbine pumps.

1920 Survey—Year after year the city was confronted with a serious water shortage, as a result of which, in 1920, the writer's firm was employed to make a comprehensive investigation of the water-supply situation, comparing particularly the further development of the ground-water supply with the filtration of Grand River, which flows directly through the city.

It was thought there was some possibility of securing a gravel-well supply and, with this in view, extensive test borings were made. These required so much time that it was apparent that the investigation would not be completed prior to the summer of 1921. Emergency provisions for meeting the water requirements of that summer, and until such time as a more comprehensive program could be executed, included equipping the 19 wells at Pennsylvania Ave. with air-lifts, thereby increasing the yield from 1 to 4 m.g.d. at an expenditure of $55,000 for building and equipment and $45,000 for mains. These measures were sufficient to tide over the dry periods of the years 1921, 1922 and 1923.



STEEL TANK FOR DISCHARGE OF AIR-LIFTS

In the meantime the investigation had been completed. It was demonstrated that it was impracticable to develop sufficient supply for the future from the gravel, but that either the deep-well supply or the filtered Grand River supply was practicable, and that so far as annual costs were concerned, taking into consideration interest and depreciation charges as well as operating costs, the two supplies were substantially equal as late as 1950. Aside from cost of water the factors in favor of the further development of the ground-water supply were its natural purity and its constant temperature of about 50 deg. F. Its development, however, becomes increasingly costly and the pumping heads increase. The hardness is 330 p.p.m.

The filtered river-water supply on the other hand is capable of indefinite future enlargement, the hardness is but 210 p.p.m. as an average and pumping heads are constant. The purity must be safeguarded by filtration and chlorination, and, as compared with the well supply, to which the people of Lansing are accustomed, the variation in temperature from 32 deg. to 80 deg. is a disadvantage. The future development of the well-water supply was determined upon as the most practicable procedure for the city.

Factors Influencing Method of Pumping—At Lansing the drift, which is of a sandy, porous character, averages approximately 50 ft. in thickness. It immediately

overlies the coal measures sandstones which are rather moderately water-bearing and which produce a good quality of water to a depth of about 600 ft. at and below which salt water is encountered. From an extensive investigation of the mutual interference of adjacent existing wells under various conditions of pumping, it was concluded that a well spacing of not less than 300 ft. for heavy pumping was desirable. The location of the well groups in the several sections of the city also afforded an excellent opportunity to test the porosity of the sandstone and its transmission capacity at various locations. The results indicated that the sandstone is relatively more porous to the east of the city along Red Cedar River. Accordingly the site selected for the future development was east of the Pennsylvania Ave. development.

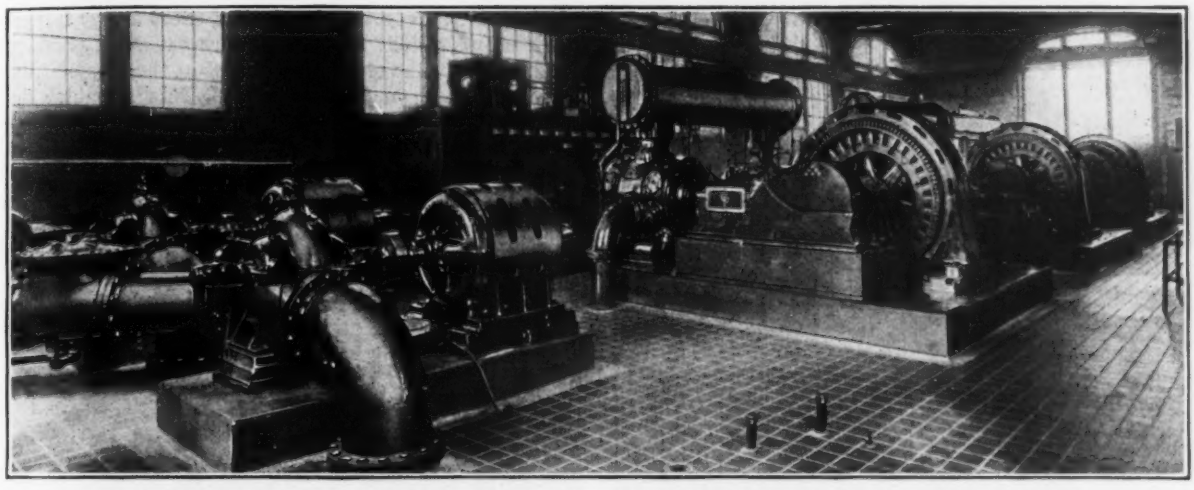
It was determined that a system of 12 wells would be required to provide for the 1930 conditions. The cost of the installation and pumping of these wells by air-lift and by electric-driven deep-well turbines was compared. Pumping by a centrally-located air-compressor station was determined upon as the most practicable. Air-lift advantages at Lansing are as follows: (a) Lower annual cost; (b) greater reliability; (c) greater flexibility under changing conditions of pumping and head.

Riverside Station Development—The 12 wells are located in a straight line paralleling Red Cedar River and at intervals of 300 to 400 ft. All wells are cased 12 in. to rock and drilled 12 in. into rock except where caving materials necessitated reducing to 10 in. to place a liner. All well piping is genuine wrought iron.

Each well was given a 24-hr. test for specific capacity when completed. The first well was sunk as a test well. Its specific capacity was tested every 50 ft. and the hole penetrated the rock until salt water was found at about 650 ft., after which the lower 50 ft. was plugged and the salt water shut off. When tested separately the specific capacities varied from 5 to 25 gal. in yield per ft. of drawdown. This fact made the balancing of the 12 wells rather difficult but was effected by regulation of the graduated air cocks at each well head.

The Riverside installation to pump the 12 wells consists of three synchronous motor-driven compressors having a delivered air capacity of approximately 5,000 cu.ft., and two low-lifts, all housed in a substantial brick building. The air-lifts deliver the water to tanks, supported upon steel towers of such height that the flow from the tanks is by gravity to a 1-m.g. reinforced-concrete reservoir. The roof of one end of the reservoir forms the main floor of the Riverside station. Two low-lift pumps operating against 100-ft. head draw the water from this reservoir and discharge it to the Cedar St. reservoirs from which the Cedar St. high-lift pumps deliver it to the city.

The air-lift equipment has a starting air pressure of 160 lb. and an average operating pressure of approximately 100 lb. The lift averages 150 ft. and the submergence 60 per cent. Tests of the equipment, extending over a period of two or three weeks, showed overall efficiencies of 34 per cent, secured by dividing the theoretical water horsepower by the actual electrical horsepower determined by switchboard readings.



RIVERSIDE PUMPING STATION—TWO LOW-LIFT CENTRIFUGALS AND THREE COMPRESSORS

Air-lifts pump the water to elevated tanks discharging into a 1-m.g.d. reservoir. The low-lifts take water from reservoir and pump to the Cedar St. reservoir from which high-lift pumps deliver it to the distribution system.

Cedar St. Station—Simultaneously with the air-lift installation at the new Riverside station, the central Cedar St. station was rehabilitated, the wells deepened and air-lift pumping equipment installed for pumping them. This installation included two steam-driven air compressors, one of the horizontal cross-compound type and the other of the uniflow-engine type, and air-lift equipment in six wells.

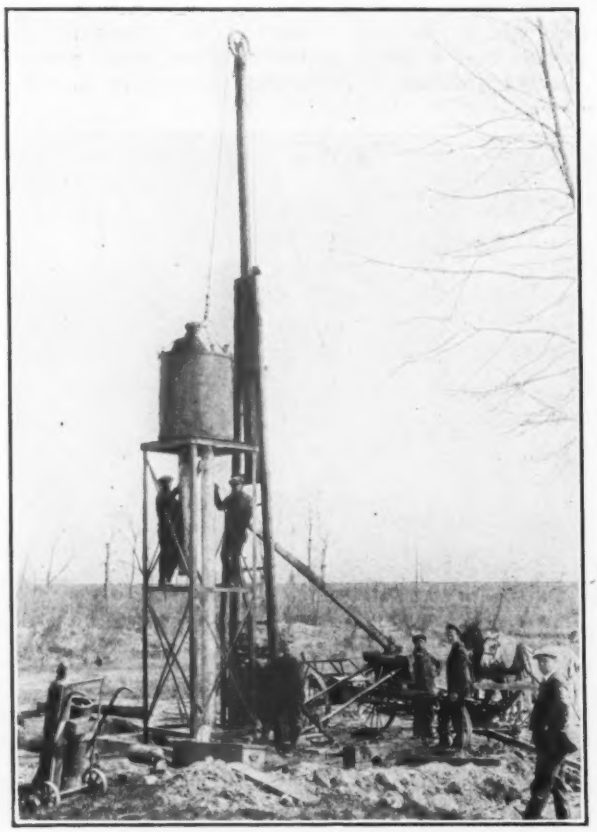
TOTAL AIR-LIFT INSTALLATION AT LANSING

	Cedar St.	Riverside	Penn. Ave.	Total
No. of Wells	6	12	19	37
Compressor cap. (delivered air) cu.ft.	3,000	4,878	1,816	9,694
High-service pumps, m.g.d.	24	*12	8	(a) 32 (b) 44
Reservoir storage, m.g.	7	1	½	8½
Continuous yield capacity m.g.d.	3	6	4	13
Short period yield, m.g.d.	4	9	5	18

* 160 ft. head only
(a) Exclusive of Riverside
(b) Including Riverside

Provision for Softening—In the engineer's investigation and report the question of ultimate softening of the well supply was given consideration. Subsequent to the

presentation of that report, a demonstration plant was operated for some months in Lansing and the practicability of softening the local water was thoroughly demonstrated. It is probable that the Lansing water supply will be softened within the not far distant future. With that in mind the Riverside station was developed as a low-lift station, the water being pumped through a 24-in. force main to the two 3.5-m.g. storage reservoirs located at the Cedar St. station. From these reservoirs, which will later be a part of a softening plant, all water is now pumped to the distribution system by the high-lift equipment in the Cedar St. station. This equipment consists of one 10-m.g.d. turbo-centrifugal, one



EQUIPMENT FOR INSTALLING AIR AND EDUCTION PIPING

Elevated tank, 42 in. in diameter, on steel towers, 14 to 23 ft. high, discharges into reservoir.

10-m.g.d. cross-compound pump and one 4-m.g.d. motor-driven centrifugal. These units are supplemented by two electric centrifugal pumps in the Pennsylvania Ave. station, having a total capacity of 8 m.g.d.

Several months' operation of the Lansing air-lift installation, particularly the severe test which it received during the dry summer of 1925, has demonstrated its complete ability to operate as planned.

All of the Lansing utilities, including water supply, electric light, power and heating, are operated under a Board of Water and Electric Light Commissioners of which Otto Zeigler is chairman. O. E. Bulkeley is superintendent for the commission. Alvord, Burdick & Howson, of Chicago, were engincers on the rehabilitation and enlargement of the water-works at Lansing.

Charleston, S. C., Builds 2,000,000-Gal. Elevated Steel Tank

Huge Tank Equalizes Pressures on City's Direct-Pumping Water System—Architectural Treatment a Major Consideration

ELEVATED tank construction in a superlative degree is illustrated in the structure recently completed for the city of Charleston, S. C. This tank of 2,000,000-gal. capacity on an 80-ft. tower is probably the largest elevated tank with a self-supporting bottom that has been built to date. However, such a capacity was fixed by the operating requirements of the direct-pressure water system rather than by any desire on the city's part to build something larger than had heretofore been built, according to J. E. Gibson, manager and engineer of the Charleston water department.

Manufacturing plants consume about one-third of the city's water supply, and in addition exert a very irregular demand, which for many years caused a pressure fluctuation on the street mains within the city of from 60 to 20 lb. throughout the day. This irregular demand also caused the loads on the pumping plant equipment to vary from minimum to maximum in a ratio of about 1 to 6. It was to overcome these conditions and to obtain safer operation that it was determined to build an elevated tank.

Description of Tank—The tank shell above the curved bottom is 80 ft. in diameter by 35 ft. high and, as shown in Fig. 2, is not surmounted by a roof. The ellipsoidal bottom is 26 ft. deep, terminating in a 14-ft. diameter steel riser pipe 54 ft. high, so that the total height of the steel structure is 115 ft. above the foundations. The foundations are some 10 ft. above the curb line. The tower is composed of 24 vertical H-section posts 80 ft. high with built-up channel struts of a T-section and channel-iron diagonals.

In architectural treatment, the tank is somewhat different from any heretofore built. Since it is to have no roof the overhanging overflow trough was designed in the shape of a battlement to relieve what would otherwise have been an unpleasingly plain sky line. The trough is 18 in. deep and 18 in. wide. The function of the overflow trough is mainly to keep residents within the neighborhood from being inconvenienced if the tank overflows, but in addition it acts as the necessary stiffening girder around the top of the tank. Connected with the trough and extending to the ground is a 12-in. galvanized-iron pipe. The balcony is in harmony with the battlement design at the top, having a rather massive vertical railing.

Design—The storage capacity required to equalize the pressure throughout the day was determined from a mass diagram plotted from the consumption curve of the 24-in. delivery line connecting the pumping plant with the city's distribution system. A storage of 1,200,000 gal. was found to permit a uniform pressure on the pumps at the pumping station throughout the 24 hours. The pumping station is about 12½ miles from the center of the city.

Some of the structural details, as well as a drawing of the complete tank, are shown in Fig. 1. Butt joints are used throughout for the suspended elliptical bottom and for the lower ring of the shell. The other shell plate joints range from quadruple to single riveted laps in

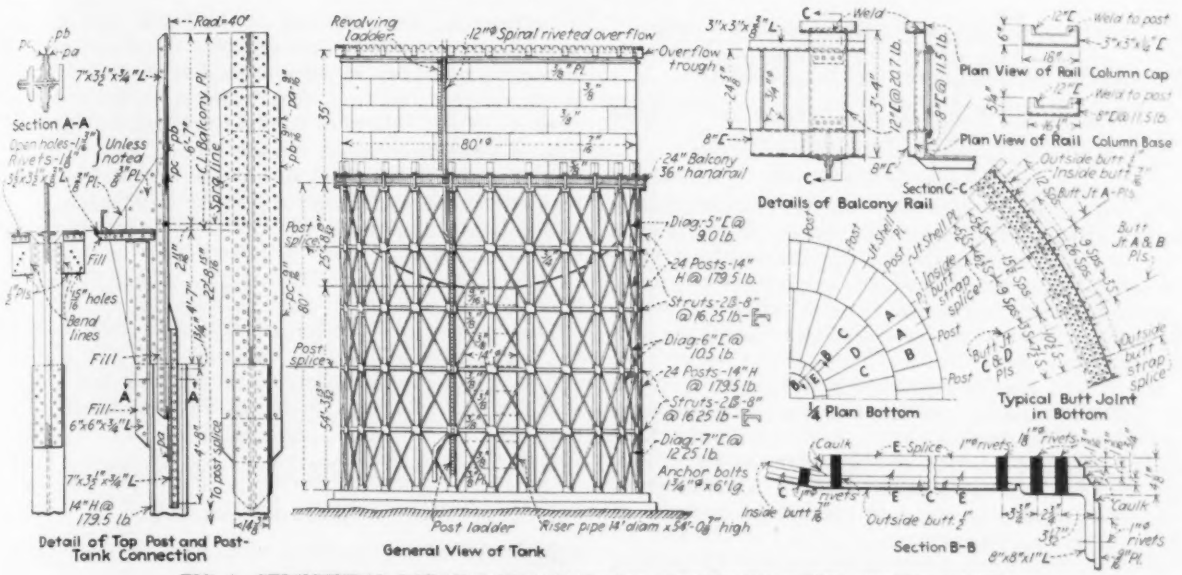

Detail of Top Post and Post-Tank Connection
General View of Tank
Details of Balcony Rail
Plan View of Rail Column Cap
Plan View of Rail Column Base
Plan Bottom
Typical Butt Joint in Bottom
Section B-B

FIG. 1—STRUCTURAL DETAILS OF 2,000,000-GAL. ELEVATED STEEL WATER TANK

the several rings. The butt straps are ½ in. on the outside and 7/16 in. on the inside, the latter being bevel-sheared for calking. Especially to be noted is the section marked BB, showing the connection of the elliptical bottom to the steel riser pipe. Here a 1⅛-in. reinforcing ring has been added, making a built-up plate thickness of 3⅝ in., an unusual amount of plate section for elevated tank construction. The detail of a portion of the horizontal seam in the elliptical bottom gives an idea of the number of rivets used. The holes in the bottom were sub-punched 1⅛ in. and reamed to 1⅛ in. in the field; other holes were punched to size.

FIG. 2—NEW 2,000,000-GAL. ELEVATED STEEL TANK FOR CHARLESTON WATER SYSTEM

The total weight of steel in the structure is 1,350,000 lb. while the total water load is 17,100,000 lb. The center foundation pier under the riser pipe was designed to carry one-sixth of the total water load and the riser pipe steel. The remainder of the total water and steel loads, plus a wind load calculated at 100 m.p.h., was carried through the tower posts to the outside foundation piers. These wind loads were calculated for the vertical tank shell and for the elliptical bottom at 20 lb. per sq.ft. and 15 lb. per sq.ft. respectively of projected area. For the tower an assumption of 50 lb. per sq.ft. of exposed area was made, 2,500 lb. per foot of tower.

The working stresses were as follows: bottom and lower ring of tank 13,000 lb. per sq.in.; remainder of tank and tower, 18,000 lb. per sq.in.; rivets single shear 14,000 lb. per sq.in. and double shear 26,000 lb. per sq. in. The post tank connection was one of the major design problems. The type adopted, shown in detail in Fig. 1, consisted of two 7 x 3½ x ¾-in. connection angles, 13½ ft. long, reinforced by a total cover plate thickness of 1⅛ in. for much of their length.

Notes on Erection—The tank was erected by a derrick with 80-ft. mast and 70-ft. boom resting on a beam supported inside of the shell of the riser pipe. The first four panels of the tower were erected with this derrick supported in the first ring of the riser. Following this the riser was erected its full height, the derrick raised to the top ring of the riser, and the remainder of the tank placed from this position. A set of radial rods from the tower posts to the bottom of the riser pipe was placed to guy it against the thrust of the derrick and also to serve as a base for the outside scaffold which consisted of a moving stage and ladders.

The steel in the tank, cylinder and overflow trough is of copper-bearing grade. It is the intention to paint the exterior of all steelwork with two coats of red lead followed with a finish coat of aluminum and to paint the interior with bitumastic enamel applied hot.

The foundations of the tank were installed by the water department's forces. The design and erection of the steelwork were by the Chicago Bridge & Iron Works.

Prehydration of Cement in New Method of Concrete Mixing

Contributed Speed and Good Concrete to Work on Baltimore Filter Plant—Centrifugal Pump Basic Equipment

DURING the construction of the new Montebello filtration plant for the city of Baltimore, Md., a large part of the concrete was mixed by hydrating the cement with the required water charge prior to mixing it with the sand and stone. There were thus two distinct mixing operations instead of the one that is conventionally used.

The results obtained from tests during construction by Willard B. Jones, resident engineer, filtration division of the Baltimore Bureau of Water Supply, have led him to make the following summary of the advantages to be gained by mixing concrete in this manner:

(1) Eliminates possibility of any lumps or balls of cement being left in the concrete.

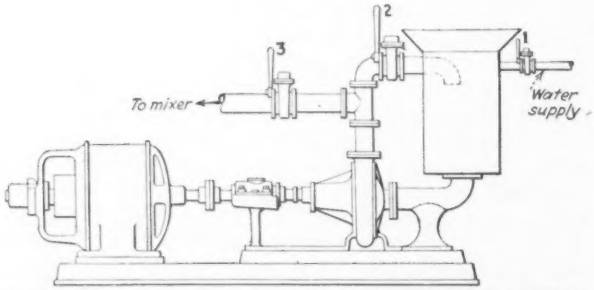
(2) Provides consistently good quality of finished concrete on removal of forms.

(3) Provides facilities for handling grout when it is desired to bond new concrete to an old pour.

(4) Makes possible a decided saving in time of mixing.

(5) Gives uniform distribution throughout the mass when using hydrated lime.

(6) Provides possibility of economical plant layout by having the hydrating machine directly at the mixer or at a distance as conditions demand.



EQUIPMENT FOR HYDRATING CEMENT BEFORE MIXING

A sketch of the equipment used for hydrating the cement is shown. This is a cylindrical drum mounted with its axis vertical and having an outlet at its bottom which is connected to the suction side of an ordinary volute pump. This pump is direct connected to an electric motor. The discharge of the pump is arranged so that it may connect either with a return line to the top of the cylindrical drum or hydrating chamber or, by valve manipulation, with a pipe main leading to the mixer. This pipe enters the mixer drum at the point where ordinarily the water alone is admitted.

The hydrating machine is located within the cement storage shed and its operation is as follows: The pump operating continuously, a predetermined amount of water is admitted to the hydrating chamber through valve 1. It circulates out of the bottom of the chamber through the pump and back into the chamber. Into this circulation cement is added. After sufficient circulation time, usually about 12 sec., valve 2 is closed and valve 3 opened, permitting the pump to force the slurry to the concrete mixer.

Short Mixing Time—Tests were conducted to determine the time necessary to turn the batch after all the ingredients were in the mixer. Specifications call for 1 min., having in mind the universal method of mixing. However, the time was first reduced to 30 sec. and then to 15 sec. Tests of finished work showed results just as good as with the minute mix. The conclusion was that a few turns of the mixer was all that was required to mix aggregates and grout thoroughly.

The large number of test cylinders broken both at the Baltimore city municipal laboratory and at the Bureau of Standards at Washington indicated that all the concrete used was of normal strength.

The machine and prehydration process are patented by A. T. Carroza, John H. Smith, and John F. Wich, all of the Carroza-Rowe Construction Co., Baltimore, who were the contractors on Montebello filter construction.

Weir-Stick for Use on Narrow Canals or Streams

Velocity Head on Rod Graduated to Give Discharge Per Inch of Weir Length—Many Used on Salt River Project

By T. A. Hayden

Assistant Engineer, Salt River Valley Water Users' Association

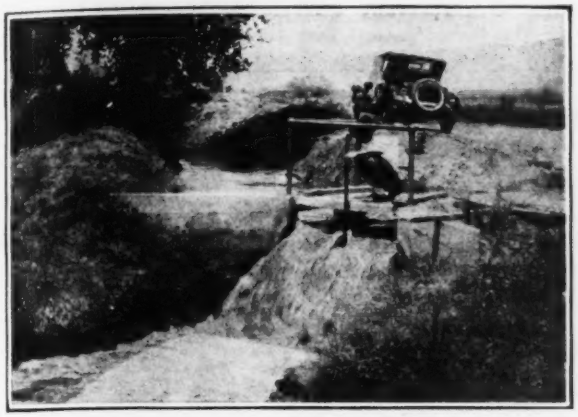
A SIMPLE direct-reading weir-stick, usable on any narrow ditch where a weir or gate with a free fall exists or can be installed, has been in use for some four years on the Salt River irrigation project in Arizona. During that time it has saved the Salt River Valley Water Users' Association, which operates the project, many thousands of dollars, and has made it possible to measure water on the 1,500 miles of canals, laterals and other ditches of the distribution system with such accuracy that water is now run and accounted for with a degree of certainty approaching train-dispatching.

In the irrigation year 1922-23, a total of 1,300,000 acre-ft. of water was run in the canal system with an operating waste of only 2,000 acre-ft., a result which was accomplished with unlined earth canals and ditches. The Clausen-Pierce weir-stick, as it is called after I. M. Clausen, superintendent of irrigation, and Ralph Pierce, chief hydrographer, Salt River project, is simply a rod 5 ft. long, 1 in. thick and 1⅜ in. wide. It is provided with a metal shoe so devised as to hold it on the crest of the weir against any tendency of the current to push it downstream. Most of the structures on the project where it is used are 4 or 5 ft. in width, and the depth of water varies from as little as an inch to as much as 2½ ft. over the crest. It is light, simple, portable, durable, cheap, sufficiently accurate for its purpose, and can be used by any ditch rider or farmer with a hand steady enough to hold it on the weir, eyes good enough to observe the "run-up" or the point to which the impinging water mounts up the graduated rod and read off the corresponding figure, and with sufficient mental capacity to multiply that figure by the length of the weir (inches). The product is the discharge in whatever unit the weir-stick has been graduated to—which on the Salt River project is Arizona miners' inches (40 sec.-ft.).

The graduation is based on the conversion of velocity head into static head and computing the discharge in terms of inch-length of weir. Taking the highest point

of run-up on the face of the rod as the equivalent of the static head, has been more or less frequently used, without attempts to compensate for the effect of the rod held in the current or to find out what that effect would be. It appears to have been considered only a rough expedient to give a general idea of the amount of water until a more exact method should be available.

Messrs. Clausen and Pierce, by many hundreds of experiments, established a relation between the width of rod and effect on discharge of different quantities



USING THE CLAUSEN-PIERCE WEIR STICK

The rod graduation at the tip of the "run-up" multiplied by the length of the weir in inches gives the discharge in whatever unit the rod has been graduated to indicate. The back of the rod is graduated to inches for use in measuring weir lengths. In use for nearly four years on Salt River Irrigation Project, Arizona.

of water over different widths of weirs, and applied the results of their experiments to practical use. It may readily be understood that the width of stick has a material effect on the discharge, which varies both with the width of the crest and depth of water. In the experiments, widths all the way from ½ to 8 in. were used and the results plotted in connection with actual measurements by standard Cipolletti weirs. It was found possible to graduate a stick so that the result would be as accurate as an ordinary weir meaurement for that particular width of stick and length of weir. But what was wanted was a device which could be used under any ordinary conditions within an allowable limit of error, and one that could be used and be sufficiently well understood by untrained men. An empirical coefficient was finally determined to be applied to the Francis formula, which with a stick 1¾ in. wide would give results within an average of 1 per cent of accuracy under the conditions to be met on the project. To make the device such that it could be placed in the hands of any ditch tender or a farmer, with the assurance that it could be used and results obtained in which all would have confidence, the face was graduated in accordance with the modified formula so that the reading on the rods to be used on this project would give directly the number of Arizona miners' inches flowing over the weir for each inch of its length. The reverse side of the stick was graduated in inches for convenience in measuring the weir length without providing a rule or tape.

A considerable number of the weir-sticks are now in use on projects in the vicinity of the Salt River project. It was first perfected and placed in use in April, 1923, and has been used, with but slight modification in details of construction, ever since. The inventors have not attempted to commercialize the stick, though they have taken out patents to protect their rights in case of a demand being created in quantity sufficient to make it worth while. The "weir-stick" is particularly adapted to the measurement of water from canals to laterals or to individual farmers, and for use by the farmers themselves for dividing a "head" in any required ratio.

The control and distribution of water on a project of 240,000 acres, such as the Salt River project, is an operating problem of considerable magnitude. It is perhaps not generally known that the Salt River project is in the power business on rather a large scale. It has a large hydro-electric plant at Roosevelt dam and four others taking advantage of drops on main canals in the valley. These plants are all operated by water as used for irrigation, and since the entire possible output, in excess of the project needs for pumping and other purposes, is absorber by nearby mines, loss of power means direct curtailment of income. It is therefore important that the control of water at all points be so positive that the greatest degree of utility may be realized. The "weir stick" brought this control and is justly credited with reduction in the cost of water deliveries, improved irrigation service and increased power income.

Water at the Roosevelt and Mormon Flat reservoirs, in the rivers, main canals and at the headgates of main laterals, is measured by permanent gages and standard ratings. But numerically the smaller measurements make up the great bulk of the operations, running to well over 100,000 per year for deliveries at farm headgates alone. The stick has created confidence formerly lacking and in case of dispute quickly settles the question at issue. C. C. Cragin, general superintendent and chief engineer of the Salt River Valley Water Users' Association, in his annual report for the year ending Sept. 30, 1923, says of the weir stick: "With any free fall of water over any ordinary crest or common wooden gate, it is accurate for all reasonable needs. Tested by the association and other projects in this vicinity on upwards of 100 standard weirs under varying conditions, the farmers soon became convinced of its accuracy. In addition, its very simplicity made it an easy matter for the farmer to see how it operates and the usual disputes over measurements in slow, dirty, weedy or crooked ditches became a thing of the past."

Port Improvements in Chile

A contract for harbor work at Antofagasta, Chile, is reported as awarded by the government to a local ñrm at $9,000,000, representing the first portion of a project estimated to cost $15,000,000. This project provides for breakwaters aggregating 4,800 ft. in length, in water 80 to 100 ft. deep. For about 700 ft. the breakwater will be of loose rock with concrete blocks on the seaward slope and a concrete parapet. Beyond that, it will be of 60-ton concrete blocks on a rubble-mound base. Quay walls will be of concrete block construction, with 33 ft. of water alongside. The completed works will give an enclosed harbor of 77 acres, with about 7,000 ft. of berthing for ships. Railway tracks will connect with the quays, which will be equipped with 30 cranes of 1½ to 3 tons capacity, a gantry crane handling heavy articles, 7 conveyors for loading nitrate into ships, 3 coal-handling machines and 36 capstans, with all machinery electrically operated.

Town of 4,000 Spends $90 per Capita for Water and Sewage

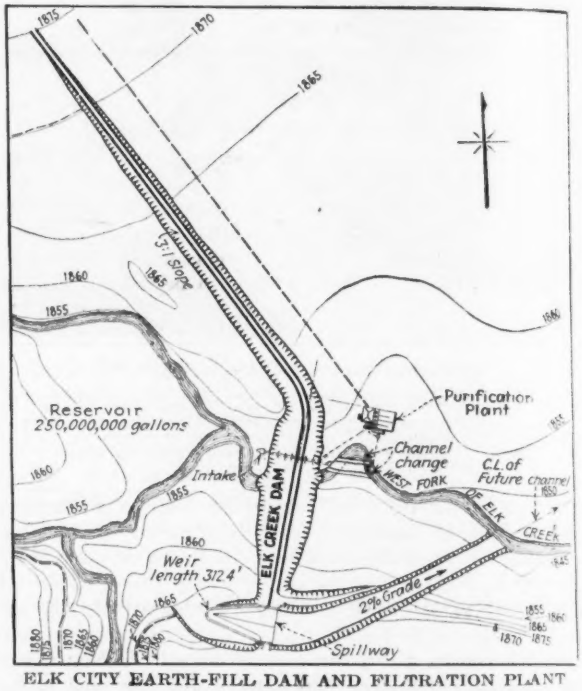
Elk City, Okla., Builds Dam Developing Underground Flow in Pervious Layer by Means of Deep Core-Wall —Novel V-Shaped Spillway Will Care for Twice Estimated Highest Flood

By Webster L. Benham
Benham Engineering Co., Consulting Engineer, Kansas City, Mo.

FOR many years Elk City, Okla., a community of 4,000 population, located in the western portion of the state, has suffered periodic shortages of water supply. The situation became particularly acute in the early part of 1925 when less than 50,000 gal. of water was available from two deep wells, there being no water in the city reservoir. The city had little or no fire protection, and there was no water for domestic and industrial consumption. An emergency existed and the writer's organization was retained to make the necessary surveys, investigations and report with recommendations for an adequate water supply, such investigations to cover both underground and surface supplies, also the necessary water-main and sanitary-sewer extensions in the city. Nearly $90 per capita was spent on the improvements, consisting of a dam which intercepts an underground flow, a novel spillway, a small filter plant and pumping station, an elevated tank, a revamped distribution system, and sewer improvements and extensions.

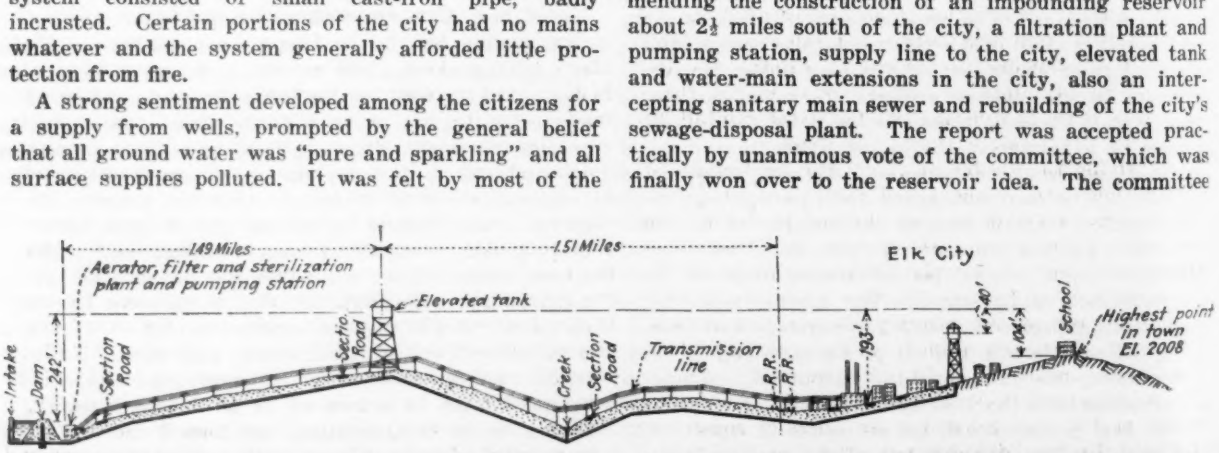
The water supply of the city consisted of a small impounding surface reservoir northeast of the city having a drainage area of less than 4,000 acres, a large portion of which was cultivated land, and two wells located near the pumping station having a combined capacity of about 50,000 gal. of water per day. The dam was of the earth type with loose stone riprap on the upstream face and provided with a small spillway. Steel sheetpiling was supposed to act as a cutoff of seepage water, but examination showed considerable seepage through the dam. The water was carried to the pumping station by gravity a distance of about 4,000 ft. through a vitrified-tile pipe line. No provision was made for filtering or sterilizing the water. In consequence, most of the time the water was muddy and unfit for domestic consumption. The water from the reservoir and wells was used alternately, or in combination, as conditions demanded. The distributing system consisted of small cast-iron pipe, badly incrusted. Certain portions of the city had no mains whatever and the system generally afforded little protection from fire.

A strong sentiment developed among the citizens for a supply from wells, prompted by the general belief that all ground water was "pure and sparkling" and all surface supplies polluted. It was felt by most of the people that no satisfactory supply of water could be obtained from any surface reservoir or "frog pond" —a term generally applied. It became evident early in the investigation that the city would have to vote



ELK CITY EARTH-FILL DAM AND FILTRATION PLANT

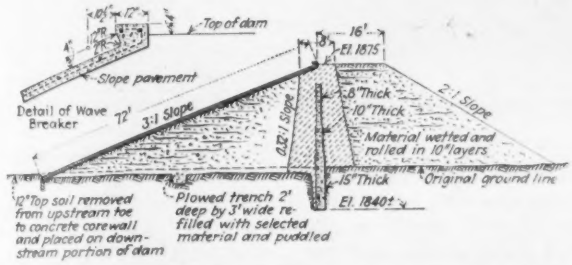
a bond issue large in proportion to its valuation for any type of supply and the necessary water mains and sanitary-sewer extensions and improvements. After several months, following the making of surveys and investigations and many meetings of the Chamber of Commerce and City Council, we filed a report recommending the construction of an impounding reservoir about 2½ miles south of the city, a filtration plant and pumping station, supply line to the city, elevated tank and water-main extensions in the city, also an intercepting sanitary main sewer and rebuilding of the city's sewage-disposal plant. The report was accepted practically by unanimous vote of the committee, which was finally won over to the reservoir idea. The committee



DIAGRAMMATIC PROFILE SHOWING RELATIVE HEIGHTS OF RESERVOIR, TANKS AND HIGH POINT IN ELK CITY

recommended that a bond election be called to provide funds for the improvements. A "campaign of education" was conducted by the Chamber of Commerce and the bonds carried by a large majority. Actual construction work started in September, 1925, and the work was completed and turned over to the city in March of this year.

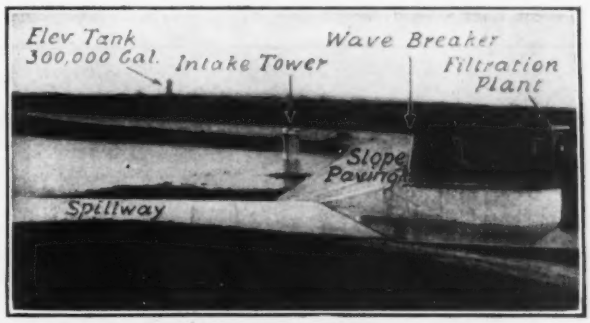
For the purpose of determining the capacity of the reservoir it was necessary to compile figures showing the rainfall in the locality of Elk City, and from this rainfall to figure out the amount of runoff expected from the drainage area of approximately 23½ square miles. Little or no data are available for runoff in this section of the state. At the proposed location for the dam and below the junction of two creeks, a gaging was made in the summer of 1925 after many months of drouth. This gaging showed a flow of approximately 0.6 m.g.d. In estimating the amount of water which would be available, we did not take into consideration the flow of water in the creek, so as to be on the safe side. The rainfall statistics were furnished by the U. S. Weather Bureau stations at Arapaho, Cloud Chief, Erick and Hammon, Okla., for the maximum, minimum and average rainfall years covering a period, as in the


Top of dam
16'
El. 1875
Slope pavement
Detail of Wave Breaker
72'
3:1 Slope
6" Thick
10" Thick
2:1 Slope
4.22:1 Slope
Material wetted and rolled in 10" layers
15" Thick
Original ground line
El. 1840±
12" Top soil removed from upstream toe to concrete core wall and placed on downstream portion of dam
Plowed trench 2' deep by 3' wide refilled with selected material and puddled

SECTION OF DAM WITH DETAIL OF WAVE BREAKER

case of Arapaho, of 31 years, from 1894 to 1924, inclusive. It was considered that a more accurate estimate of the actual rainfall in the vicinity of Elk City could be had by averaging the data of the four stations than by taking the records of any one station, inasmuch as the two nearest stations, Erick and Hammon, were not established until 1904 and 1913 respectively. It was noted that the average rainfall as recorded by the four stations was very close to the average of the wettest and driest year. In addition to data of rainfall for the maximum, minimum and average rainfall years a table was compiled showing the record of rainfall for the 3-year period of minimum rainfall, that is, the three consecutive years having the smallest total rainfall, as recorded by the Weather Bureau at Erick.

After giving the matter of runoff for the locality of Elk City much study, and based upon past experience on reservoirs in Oklahoma, we decided to divide this runoff into three parts, and divided the year as a "water year," representing the full annual cycle change in hydrological conditions. In this cycle we figured the "storage period" as covering the months of May and June; the "drawing period" as the months of July to September, inclusive; and the "replenishing period" as the months of October to April, inclusive. For the "storage period" we calculated an average runoff of 20 per cent, for the "drawing period" a runoff of 5 per cent, for the "replenishing period" a runoff of 10 per cent, making an average throughout the year of 10 to 12½ per cent, depending upon the period of rainfall. These percentages were considered reasonable, due to the fact that for two months of the heaviest rainfall we calculated only a 5 per cent runoff, while on portions of the drainage area the runoff would probably be as high as 30 per cent. It was estimated that at least one-half of the drainage area was pasture land and about one-half cultivated land. The fact that we disregarded the normal flow of Elk Creek (which would probably average 0.4 m.g.d.) gave an added factor of safety to our assumptions. The year of maximum rainfall was in 1923, when 41.18 in. were recorded; the



THIRTY-FOOT PAVED EARTH DAM, ELK CITY
Looking over spillway along dam, 300,000 gal. tank on horizon, filter plant below dam opposite concrete gate chamber.

minimum rainfall of 11.33 in. was recorded in 1910; the average rainfall was 27.23 in. The three consecutive years of minimum recorded rainfall were 1909, 1910 and 1911, with 17.39, 9.72 and 29.57 in. Calculating the amount of runoff available from the catchment area, based on the year of minimum rainfall and for the three-year period, it was found that a reservoir of 250-m.g. capacity would be ample to take care of the requirements of the city for a reasonable period in the future. From these tables and graphs we developed and worked out the "drawdown" of the reservoir during various periods of the year, estimating the daily average consumption of the city as 0.5 m.g.d. for the months of April to September, inclusive, and 0.4 m.g.d. for the months of October to March inclusive, and estimating the total annual evaporation as 50 in. of water per year, of which 40 in. occurs during the six months from April to September.

The dam is of earth, with a concrete cutoff core-wall approximately 850 ft. in length, and a shallow dike about 1,000 ft. long. The maximum height of the dam is 30 ft. and the width at the top is 16 ft. Test borings made prior to the preparation of the plans showed stratified layers of clay, red sandstone, packed sand, quicksand and shale, necessitating the construction of an impervious cutoff core-wall extending through the strata of water-bearing sands and into a solid formation to prevent seepage of water through and under the dam. A trench 3 ft. in width was cut by a trenching machine through earth and clay to the shale formation. Test holes every 10 ft. were sunk into the shale and rock to determine their depth, and it was found that between layers or strata of shale and sandstone there existed alternate layers of sand and some gravel. As the pitch of the sandstone was toward the east, it was deemed advisable to carry the concrete core-wall through these layers into a deeper rock stratum in order to seal the water-bearing formation which out-

cropped to the west within the wetted area of the reservoir, thus perfecting a seal and preventing the loss of water through these strata under the dam. It was necessary to carry the core-wall as deep as 30 ft. below the ground level for several hundred feet across and adjacent to the original creek bed. Gagings of the seep flow in Elk Creek and tributaries at the dam taken in the summer of 1925 showed a weir measurement of about 0.6 m.g.d. This flow practically ceased in September and October, when construction work was started, and an investigation showed that the water sank into the strata along the creek and came out below. The trench adjacent to the concrete core-wall in the trench on the water side was filled with a selected clay and a clay puddle was filled in adjacent to the core-wall.

COMBINED FILTRATION PLANT AND PUMPING STATION

Aerator in front of chemical house precedes baffled mixing chamber where flow is 5.6 ft. per minute with detention period of 26 minutes. The maximum velocity is 10 ft. per min. Two settling basins have combined capacity of 100,000 gal.

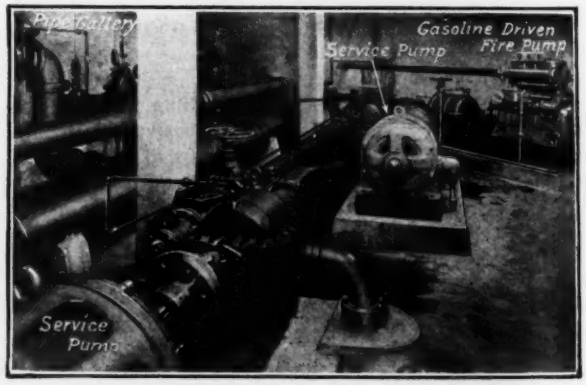
It was interesting to note, no rain having fallen, that as the concrete cutoff core-wall was put in the flow of the creek gradually increased, until at the point of closure it was recorded at approximately 1 m.g.d. The core-wall sealed the understrata, causing the water in the underground formations to back the water up in these strata and in turn causing the water to flow out above and then into the reservoir. As proof of this, a 2-in. hole was drilled about 15 ft. deep in the creek bottom above the dam and it was found that the water flowed under pressure from a hydrant installed at this point.

The slope of the water side of the dam was made 3 to 1 and that of the downstream side 2 to 1. An exceptionally good red clay containing a certain amount of sand was available for the puddle adjacent to the core-wall, while the material for the slopes was a selected material suitable for the purpose. Some stripping was necessary to obtain the material for the puddle. The fill of the dam was made in 12-in. layers by wagons loading from an excavating machine, kept wet with sprinkling carts, harrowed and rolled with a specially constructed roller so as to prevent future settlement.

The slope pavement on the water side consists of a reinforced-concrete slab 4 in. thick laid in sections and provided with expansion joints of asphalt. As a protection from slipping a curb footing set in solid ground at the heel of the dam or the foot of the slope was constructed. The pavement extends to the top of the dam and is provided with a wave-breaker.

The spillway of the dam is of rather unique construction, being V-shaped of reinforced concrete, and designed to carry 10,000 sec.-ft. of flood water at a depth of 4.5 ft. over the crest of the spillway. This amounts to 425 sec.-ft. per square mile. The spillway is constructed entirely in excavation, on solid ground, about one-half of the excavation being through solid and loose rock. The total length of the spillway along the crest is 312.4 ft. exclusive of the 1:4 slope at abutments. The purpose of the 1:4 slope is to eliminate end contractions. The cross-section of the center discharge channel is designed to carry from three to four times the flow over the spillway weir due to turbulence of the water. In order to determine the size and capacity of the spillway, there being no data other than high water-marks along Elk Creek, cross-sections of the creek and adjacent banks were made and the amount of flood water calculated. A maximum flow of 5,000 sec.-ft. was indicated and the spillway was made to carry twice this amount, or 100 per cent more than the highest calculated flood. The type or shape of spillway was thought most adaptable to local conditions for foundations and stability.

The intake is of reinforced concrete. Removable trash racks and screens are set in the structure. Intake gates are provided so that the water may be taken out of the reservoir at different levels. Two 12-in. cast-iron pipes extend through the dam to enable the water to flow by gravity to the filter plant to a depth of 8 ft. below the spillway, below which level low-duty pumping is necessary. These lines are set in concrete collars and partially in concrete to prevent slipping and leakage. By a system of connections and valves, either or both of these lines may be used for draining or for feeding water to the filter plant.



INTERIOR OF ELK CITY PUMPING STATION

Showing two motor-driven service centrifugals and one emergency gasoline unit in combined pump room and filter pipe gallery. Discharge from all units is into far end of 12-in. pipe to left of columns thus giving long run ahead of venturi meter just outside of picture to left. Other piping at left is filter gallery installation.

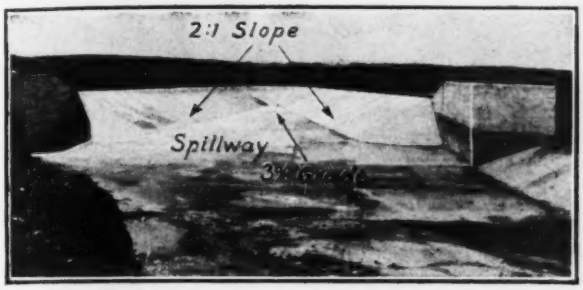
The filter plant and pumping station are built under one building. The water flows through an aerator for removal of vegetable gases, then to a mixing chamber arranged for horizontal and vertical baffling, thence into the coagulating or settling basins, arranged so

that these basins may be operated singly or in multiple. There are two rapid sand filters having a capacity of 0.5 m.g.d. each. All water is treated with liquid chlorine.

The high-duty pumps are of the horizontal, split-case, motor-driven centrifugal type, and have a capacity of 350 g.p.m. operating against a total head of 285 ft., and 500 gal. operating against a total head of 295 ft.

For fire protection and for emergency use in case of shut-down of power or interruption of service due to line trouble, a marine-type gasoline pumping engine was installed for high-service emergency use. This pump has a capacity of 750 g.p.m. against a total head of 300 ft. For low-duty pumping (in the event the water level in the reservoir falls 8 ft. below spillway level), there is provided a centrifugal pump having a capacity of 500 g.p.m. against a total head of 15 ft.

The water has little or no permanent hardness and about 15 grains of temporary hardness. It is considered an unusually soft water for this region of the country. Three months before the dam was completed water was pumped to the city, during which time there was no rainfall, but in spite of this fact, the water level in the reservoir rose, showing that the flow from the springs and underflow backed up by the core-wall was more than sufficient to take care of consumption and evaporation during this period. Recent rains have practically filled the reservoir.



SPILLWAY OF ELK CITY WATER SUPPLY SYSTEM
V-shaped spillway designed for 10,000 sec.-ft., which is twice largest flood of record. Slope at abutments is to eliminate end contractions.

The cost of the entire project, including real estate, water mains and sewer improvements and extensions, was $356,000. All work was constructed by the Standard Paving Co. of Tulsa, Okla., under the plans, specifications and supervision of the Benham Engineering Co., consulting engineers, Kansas City, Mo., and Oklahoma City, Oklahoma.

Water Users to Operate Reclamation Project

Operation of the Boisé reclamation project in Idaho by the water users is to begin within a short time. The Nampa-Meridian Irrigation District within the project made a contract with the government in March to take over operation under the terms of the 1924 amendment to the reclamation law, and on April 27 the Boisé-Kuna District signed a similar contract. The third of the districts in the project, the Wilder District, is expected to join with the other two shortly, completing the contractual arrangement. Operation of the project is to be managed by a board of control composed of representatives of the three districts.

High Duty of St. Paul Cross-Compound Pumping Units

IN THE five-year program of water-works improvements at St. Paul, Minn., just being completed, is an unusual combination of three horizontal cross-compound pumping engines. The water ends are identical, each having a capacity of 15 m.g.d. but the steam ends vary to take care of three different heads, 70, 175 and 220 ft. The topography requires three main distribution reservoirs which the heads named serve. Extremely high duties were obtained in the installation tests, the approximate figures per 1,000 lb. of steam, in millions of foot-pounds, being 160 for the low-lift and 182 for both the intermediate and high lifts. J. W. Kelsey, general superintendent of the water department, has recently furnished the following data on the plant and the 1925 operating performance, to which a summary of the contract test results is appended:

By reason of the fact that the water from the chain of lakes feeding the system is taken by gravity through the filtration plant it was deemed economical to combine the pumping station with the filters under one roof.

The chemicals and the coal for the boiler room are brought over a trestle into the plant. The chemicals are then shoveled from cars to bins underneath the track and the coal is brought in in hopper-bottom gondolas and dumped directly into a storage bin beneath the tracks. The bottom of the storage bin is divided into ten conical-shaped hoppers—five on either side of the center line. The bottoms of the hoppers are fitted with standard manual controlled gates, through which the coal can be delivered to either one of two belt conveyors which carry the coal through a crusher from whence it is delivered to an elevator which carries it to an overhead hopper directly in front of the boilers. The outlet of the overhead hopper is provided with standard coal gates through which the coal is directed into a traveling larry where it is weighed and then delivered directly into the stoker hoppers.

ESSENTIAL FEATURES OF TEST OF PUMPING UNITS, WATER-WORKS OF ST. PAUL, MINN.

	Low-Lift		Intermediate		High-Lift	
	Test	Guarantee	Test	Guarantee	Test	Guarantee
Total dynamic head, lb. per sq.in.	28.96	30.34	75.96	75.86	94.74	95.26
Combined mech. eff. entire unit, per cent	89.92	.....	95.95	.....	91.16	.....
Thermal eff. of entire unit, per cent	17.16	.....	19.41	.....	19.41	.....
Duty per lb. of steam, ft.-lb.	159,900	153,000	182,400	167,000	182,200	169,000

The boilers are the horizontal water tube type and carry 200-lb.-gage steam pressure. The steam is superheated and delivered to the engine throttle at about 100 deg. superheat. Boilers are equipped with underfeed stokers and the ashes are conveyed by means of a vacuum system to a hopper in the bottom of the smokestack, whence they can be delivered through a chute to a truck and hauled away with a minimum of manual labor. The boilers are also equipped with draft gage, boiler feed-water regulators and non-return valves. All the auxiliaries, including the stoker engines, boiler-feed pumps, and the force-draft fan, are steam-operated. The exhaust from these units is used to heat the boiler-feed water by an open feed-water heater.

During 1925 all three pumps discharged 7,670 m.g. by plunger displacement and 3.47 per cent less by venturi meter, which represents the slip. The average dynamic heads pumped against were 64, 177 and 177 ft. respectively for the low-lift, intermediate and high-lift units. For the 4,020 tons of coal, which had an average of 13,252 B.t.u., $5.28 per ton was paid. The station duty in ft.-lb. per B.t.u. was 80.7, in ft.-lb. per 100 lb. of coal it was 106,944,000. The pumping cost was $7.70 per m.g., or 5c. per ft. head. Contract tests carried out under the supervision of I. G. Ringstrom of the water department and M. C. Shaw, representing the Allis-Chalmers Co., the manufacturers of the pumps, are given in the adjoined table.

Mexican Federal Road System Makes Progress

Organization Like American Highway Commission —Blanket-Contract on Cost-Plus Basis Awarded American Firm

By P. K. Schuyler
Bridge Engineer, Comisión Nacional de Caminos, Mexico City, Mexico

THE MEXICAN Congress on March 19, 1925, passed laws creating a system of federal roads throughout the republic, and provided funds for the construction of these roads by placing taxes on gasoline and tobacco. The gasoline tax of three centavos per liter,

FIG. 1—ROUTE MAP OF MEXICAN NATIONAL ROADS

which is equivalent to 5.7c. (American) per gallon was placed on all gasoline whether it was to be used for domestic purposes or for export. This tax is collected from the producing companies. The amount collected from this gasoline tax is placed in a fund to be used only for road construction and maintenance. All the funds collected from existing taxes on the manufacture of tobacco were also diverted solely to road construction. In case the total of the two taxes does not amount to $500,000 (American) per month, the Treasury Department was authorized to issue notes to make up the $500,000, which is the amount that was deemed necessary for the proposed highway program. At the present time the sum of these two taxes is averaging $400,000 per month and is increasing as the rate of production of gasoline increases. By means of these tax laws a fund for expenditure on road work is guaranteed of $6,000,000 per year. There are at the present time about 25,000 automobiles operating in the Republic of Mexico, a large majority of these cars being in Mexico City. Funds derived from licensing these cars are at the present time collected by the various States, and used for sundry purposes. In time it is probable that these funds will also be diverted to road construction as is customary in the United States.

Organization—Responsibility for the administration and expenditure of these road funds was placed by law in the Comisión Nacional de Caminos, which is composed of three members, one member appointed by the Secretary of Treasury, another member appointed by the Secretary of Communications and Public Works, and a third member selected by the taxpayers themselves. The three members of the present Comisión are: Leon Salinas, P. Luna y Parra, and F. B. Puga. This Comisión controls road work in Mexico in a manner similar to that of the various state highway commissions in the United States. It was desired to introduce into Mexico the methods of road construction which have been adopted and perfected in the United States, so the Comisión believed it advisable to let all their work to one contractor on a force account arrangement, the Comisión to furnish the necessary machinery and equipment while the contractor was held responsible for the carrying out of the construction work. Byrne Bros. Construction Co., of Chicago, was the firm selected by the Comisión to handle the construction.

Construction Program—The program of construction outlined by the Comisión consists of a total mileage of 1,337 miles, distributed as follows: Mexico City-Acapulco road 285 miles; Mexico City-Puebla road 82 miles; Mexico City-Laredo road 780 miles; Chiapas road 190 miles. When work was commenced in September, 1925, on these roads large portions of them were entirely impassable to automobile traffic, and could be used only by pack trains or burros. The Mexico City-Acapulco road, as can be seen from the map, Fig. 1, connects Mexico

FIG. 2—MOUNTAIN CONSTRUCTION ON PUEBLA ROAD

City with the port of Acapulco, which is one of the finest harbors in the world. This is the port that Hernan Cortés selected at which to build and launch a fleet on the Pacific Ocean. There is at the present time no road or railroad connection from this port to the interior of Mexico, and all the products which are loaded or unloaded here must be transported to the interior on burros. The Mexico City-Puebla road, Fig. 2, connects the capital with Puebla, the third largest city in the Republic of Mexico and of considerable industrial importance. This road passes very near the foot of the active volcano Popocatepetl and crosses a pass at an elevation of 10,500 feet. The road at the present time has been worked on for its entire length and is in very good shape. A number of lines of buses have recently been established, and are operating between Mexico City and Puebla. The cost of transportation by these buses is considerably less than the railroad fare and their time is one hour less than the railroad.

The Mexico City-Laredo road will connect Mexico City with the United States passing through the cities of Pachuca, Victoria, and Monterey. At the present time it is impossible to travel from the United States to Mexico City by automobile, but upon completion of this road it is expected that a large number of automobile tourists will annually visit Mexico.

The road being built in the state of Chiapas which is the most southerly state in the republic passes through a country which is very rich in agricultural possibilities. The road starts at the station Arriaga on the Pan-American R.R. and runs across the state of Chiapas to

FIG. 3—OIL-TREATED VOLCANIC GRAVEL

the Guatemala frontier. This state has no railroad facilities, and has never before had a road passable to automobiles at all seasons of the year. The construction of the roads above mentioned will serve a number of useful purposes; employment is being provided for a large number of men on their construction; the movement of troops will be greatly facilitated thereby reducing the chances of success of a revolution; automobile communication will be established between points where today the only source of communication is burro back; rich mining regions will be opened up.

Types of Roads—In Mexico, the country to the north is desert, in the central portion are very high mountain ranges, while along the coast and in the southern portion tropical jungles are encountered. These different topographical features make necessary the use of various types of roads to suit local conditions; top soil and gravel roads are being constructed wherever material is available in the northern part of Mexico; in the mountainous regions of the central part gravel and penetration macadam are being used; in the vicinity of Mexico City a volcanic stone named "tezontle" is being laid and then given three oil treatments. This type of road, Fig. 3, is meeting with great success and proves economical. The effort is being made to build as many miles of road as possible, passable at all times of the year, rather than to build fewer miles of a higher type of road. The progressive type of road construction is being used that is, the location, base and drainage structures are such that a higher type of road may be constructed later. Machinery required for this construction program has been purchased in the United States; however, it is being found that in many places hand labor which is very efficient when capably directed and costs $0.75 (American) per day is more economical than machinery.

Bridge Construction—The bridges and culverts to be built presented many interesting problems. Reinforced-concrete bridges of which at the present time there are practically none, are being introduced and prove very satisfactory. Rubble masonry is being used in locations where the transportation facilities are poor. Structural steel is very expensive in Mexico, costing over twice as much as in the United States, whereas concrete costs about the same; therefore structural steel is being used only where conditions are such that reinforced-concrete spans are not suitable. Standard plans for the culverts and bridges have been worked up, these plans being modeled after the North Carolina standard types. The deck girder type is the most economical. Several large reinforced-concrete arch bridges are now being designed; one of them consists of three 170-ft. arch spans with deck girder approaches. Conditions are such in the northern part of Mexico that overflow bridges appear advantageous. The streams rise very rapidly, being similar to those in Texas, but the floods subside fast. If bridges were designed to take care of these exceedingly high flood flows their cost would be excessive; therefore, overflow structures are being built and at times the water will pass over the bridge and

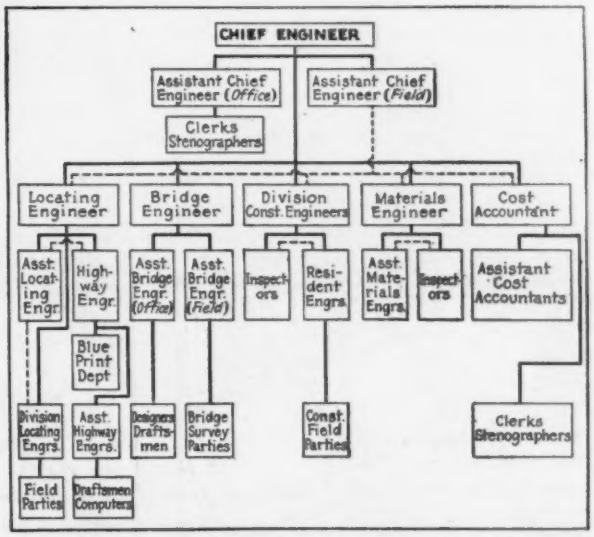


FIG. 4—ENGINEER ORGANIZATION FOR MEXICAN ROADS

roadway. The specifications used on all the bridge and culvert work have been adapted from the latest report of the Committee of Bridge Specifications of the American Association of State Highway officials.

Engineer Organization—The Comisión Nacional de Caminos has employed Charles M. Upham, state highway engineer of North Carolina, as consulting engineer on the engineering work for this road program. Mr. Upham has selected as chief engineer C. N. Conner, who, as well as a considerable number of the heads of the various engineering departments, received his training with the North Carolina organization. The chart, Fig. 4, shows the engineering department organization, which is modeled after that which has been perfected in North Carolina. Mexican engineers are employed wherever possible and are rapidly being trained to fill the higher engineering positions.

Plan for Simultaneous Control of All Traffic in District

Applies One-Way Traffic Idea to Separate Halves of All Streets—Four Intervals of Movement at Intersection Make Complete Cycle

A PLAN for simultaneously controlling all traffic within a congested district of a city is being advanced as containing several unusual features and advantages. It differs from the usual plan in that four intervals constitute a complete cycle of movement rather than two. Thus, at any intersection traffic moves in only one direction at a time, i.e., there is no east-west traffic interval, but an east traffic interval and a west traffic interval. Therefore, as shown in Fig. 1, traffic approaching the intersection can, on the "Go" signal, proceed straight ahead, turn right or turn left; there is no oncoming traffic to interfere with left turns as is the usual case.

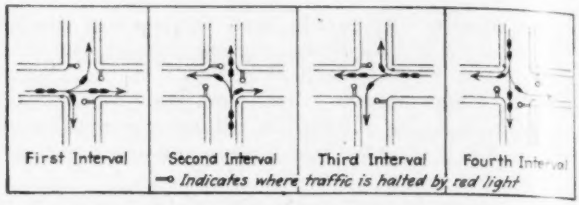


FIG. 1—DIAGRAM OF SUCCESSIVE CONDITIONS AT A STREET INTERSECTION

The above remarks apply to a single intersection. Extending the system to a district is graphically shown in Fig. 2. It will be noted that Fig. 1 is a picture of conditions at intersection *A* in Fig. 2 during each of the four intervals. Furthermore, in comparing conditions at different intersections, it will be noted that traffic moves in one direction at every alternate intersection, *B* and *C*, and in the *opposite* direction at the intermediate intersection *A*. In other words, instead of allowing traffic moving in opposite directions to cross the same intersection at the same time, vehicles cross alternate intersections in opposite directions simultaneously. Thus, in interval 1, Fig. 2, traffic is crossing *A* in an east direction only and *B* and *C* in a west direction only. This method, in effect, applies the one-way traffic idea to the separate halves of each street.

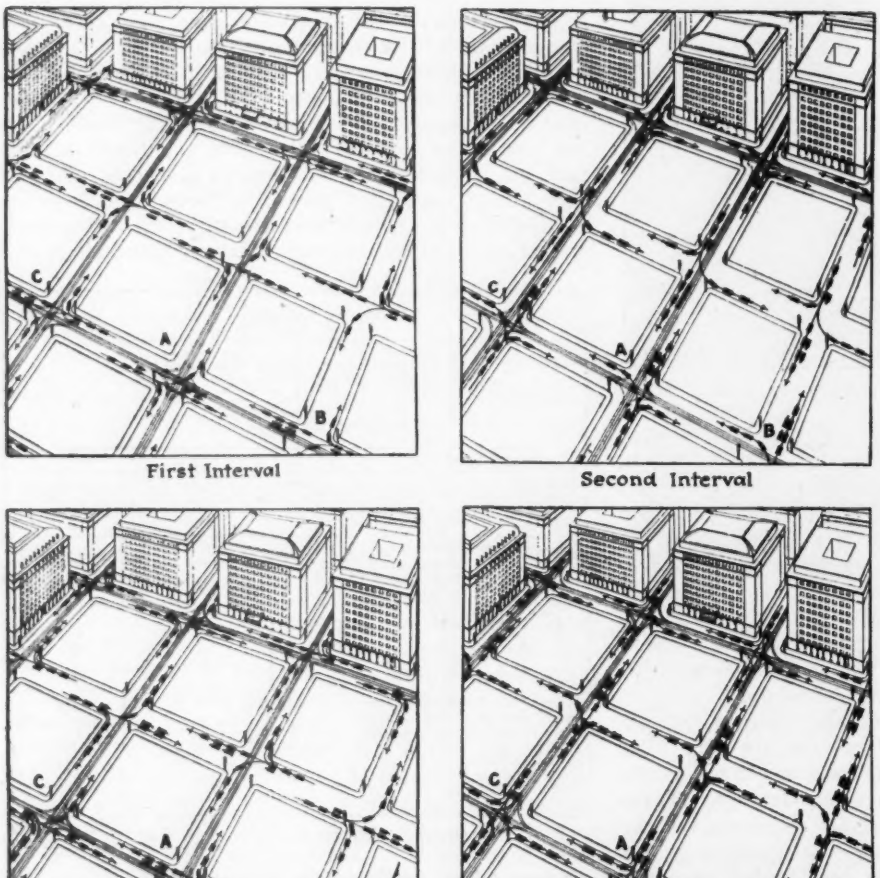


FIG. 2—COMPLETE CYCLE MOVEMENT OF FOUR INTERVALS VISUALIZED FOR A TRAFFIC DISTRICT

In regard to the time interval, the fundamental principle of the plan is that the length of this interval shall be one-half the period of time that it takes a street-car or other vehicle to travel one block, unload, load and be ready to go again. As an illustration, assume that 50 sec. is the time required and therefore a 25-sec. interval is theoretically necessary. A vehicle starting from *B*, interval 1, Fig. 2, would be half way to *A* when interval 2 began and would be at *A* when interval 3 began. This interval, it will be seen, permits the vehicle to again proceed on its course. Proper time intervals and co-ordination of signals, it is claimed, will permit a vehicle to proceed through the district almost without interruption.

The plan employs a standard system of lights. Either one signal at the center of the intersection or four at the various corners can be used. It is suggested that the signal show in one direction only in order to compel drivers to stay back of their own signal and thus free the crosswalk for pedestrian traffic.

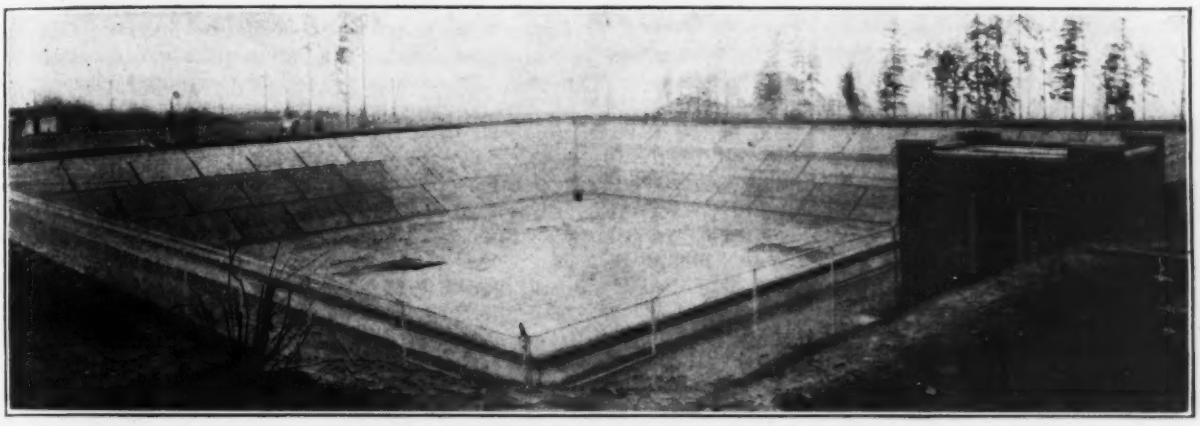
This plan is advocated by Hugh E. Young and Eugene S. Taylor, who have applied for patents on the system.

Unique Reservoir Lining for Port Angeles, Wash.

Concrete Slabs on Side Slopes Supported by Beams Beneath Joints Which are Tied Into Curb and Footing

By M. P. Hatcher and E. L. Ferguson
Office Engineer and Supervising Engineer, Burns & McDonnell Engineering Co., Kansas City, Mo., and Los Angeles, Calif.

PORT ANGELES, Wash., a city of possibly 10,000 people, has recently completed a water-works program involving the expenditure of $625,000. About $280,000 of this amount went for the purchase of the privately-owned system, the remainder for the development of a new 11-m.g.d. supply, a 6-m.g. reservoir and improvements to the distribution system. With the old supply of about 3 m.g.d. the city now has a total available supply of 14 m.g.d. or 1,400 gal. per capita. The point of major interest in the new works is the 6-m.g. earth reservoir, and particularly its reinforced-concrete slab lining supported by reinforced-concrete beams.



CONCRETE-LINED RESERVOIR, PORT ANGELES, WASH.

The new supply is taken from Morse Creek, a stream carrying the runoff from the melted snows of the Olympic Mountains. A concrete dam about eight miles from the city diverts water through a 24- and 20-in. gravity wood conduit to the 6-m.g. reservoir, from which the water flows by gravity to the distribution system.

The reservoir is in excavation and embankment, with side slopes 1.75 to 1 and top bank widths of 15 to 30 ft., being widest on the high embankment side. The reinforced-concrete lining slabs are 5 in. thick on the slopes and 6 in. on the bottom, supported at the joints by reinforced-concrete beams. The concrete curb and footing are tied into the beam grid system, forming a basket-like support for the slabs. The slabs are separated from the beams by asphalt expansion joints.

Slabs on the side slopes are constructed about 17 ft. square and are reinforced with cross ribs on the bottom which not only add to the strength but provide also against slippage of the slab along the slope. The bottom slabs are about 22 ft. square and have no cross ribs.

An inlet control house was provided which fixed the elevation of the lower end of the hydraulic grade line of the conduit from the dam. The control house was arranged to allow the surplus of water supplied by the pipe line to waste into a nearby stream, thus permitting the conduit to flow constantly at full capacity. The curb wall of the reservoir was constructed to a height of 18 in. above the ground and provided with an overhanging coping to exclude small animals. The reservoir site was inclosed with a 6-ft. woven wire fence, with barbed top wires to prevent climbing. All reservoir connections below the embankment were of cast-iron pipe, laid in trenches in the natural earth with 12-in. concrete cutoff walls not over 20 ft. apart. Each pipe length was tested for leaks before the trench was covered with embankment material.

LINING THE PORT ANGELES RESERVOIR
Each slab joint supported by a beam. Cross ribs on the slope slabs add strength and provide against slipping. Slabs and beams and the slabs themselves separated by asphalt.

Soil conditions were mostly favorable to reservoir construction. The soil was mainly a very hard compact glacial till containing sufficient clay with the sand and gravel to compact well under rolling. Part of the excavation was in a hardpan which required blasting and a part in blue shale-like sandstone which was plowed loose. Both of these materials were used in the embankment, responding readily to the application of water and the action of the roller.

For the greater part of the excavation, totaling 22,000 cu.yd., the equipment consisted of three 2-ton crawler tractors with fresnos, one 5-ton crawler tractor with heavy duty plow, and a 10-ton steam roller. The fresnos were loaded and dumped from the tractor seat. The specifications required that the embankment be rolled in layers not exceeding 12 in. in thickness but it was

POURING SLABS, PORT ANGELES RESERVOIR

found that the roller could be used continuously almost as cheaply as intermittently; consequently the rolling was applied to 3- to 4-in. layers as the material was deposited by the fresnos. Observation indicated that one roller could roll and compact satisfactorily all the material that could be handled by five or six fresnos—probably 50 or 60 cu.yd. of material per hour—when the length of round-trip haul was about 400 feet.

An interesting feature of the reservoir design is the underdrainage system. The general slope of the topography in the vicinity of the site, from the mountain foothills to the Sound, causes a movement of ground water in all seasons. A complete underdrain system, both on side slopes and bottom, was provided to carry away this ground water and any leakage that may occur in the reservoir. Three-inch tile drains were laid on 0.5 to 1 per cent grade in a gravel-filled trench below the floorbeams and were so located that no point on the floor was over 11 ft. from a drain tile. Tile on side slopes was placed below the horizontal beams. Drain lines were also placed around the reservoir beneath the embankment near the intersection of the original ground line and the side slopes. A deep cutoff drain was placed along the upper side of the reservoir to intercept the flow of ground water in the direction of the reservoir. This drain was constructed of 10- and 12-in. drain tile in a trench extending to the grade of the reservoir floor. The trench—20 ft. deep at points—was filled with 9 in. of gravel separated from the remaining earth fill with used lumber. All drain lines were brought together in a 12-in. header and carried to waste. Measurements of the flow from the outlet showed it to be about 25 gal. per min. About $6,000 was expended on the underdrain system.

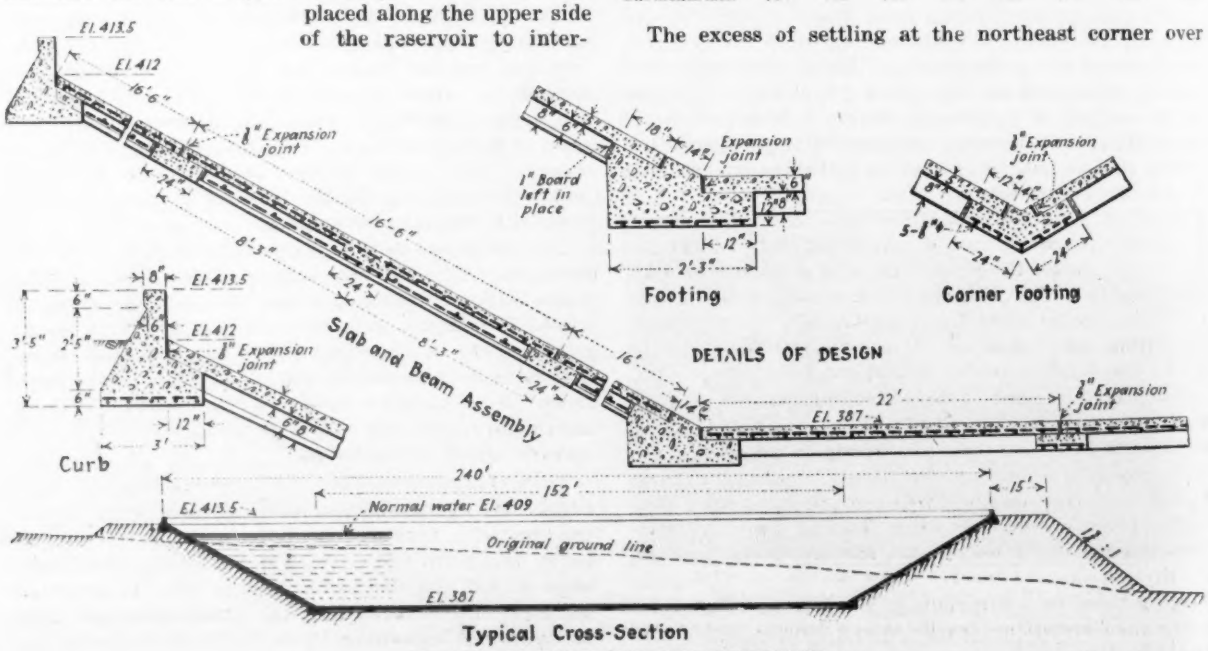
The floor slabs were separated from the footing beams and from each other by asphalt expansion joints. The beam surface was troweled smooth and brushed with a priming coat, using about 10 lb. to the square. Following the priming coat the beams were mopped with about 30 lb. of asphalt per square. The asphalt used had a melting point between 160 and 180 deg. F., with a penetration over 15 at 32 deg. F. and between 30 and 40 at 77 deg., and was applied with a melting pot temperature of 325 to 350 degrees.

Lap siding, covered with sheet iron to facilitate removal, was used in forming the joints between adjacent slabs. The metal surface of the strip was coated or dipped in oil to prevent adhesion to concrete. Concrete was poured against the siding strip and the strip removed. The joints were then thoroughly cleaned and all dust and foreign matter removed with compressed air. Following this operation the joints were sprayed with primer and filled with hot poured asphalt. To prevent the asphalt from running down the vertical joints on the side slopes, it was necessary to cover the joint with tar paper weighted with sand bags as the pouring progressed up the slope.

Elevations were noted on the corners and sides of the reservoir curb immediately before and after the filling in order to determine settlement. The total settlement in feet immediately after filling and a month later was:

	N.E. Cor.	East Side	S.E. Cor.	South Side	S.W. Cor.	West Side	N.W. Cor.	North Side
Immediately after filling	.04	.02	.00	.00	.01	.01	.02	02
One month later	.04	.02	.01	.01	.01	.01	.02	02

The excess of settling at the northeast corner over



DETAILS OF PORT ANGELES RESERVOIR

other points may be explained by the fact that this point in the embankment was the last to be brought to grade, being the point of exit of the fresnos in the removal of excavated material. The material used to fill this corner was taken out in industrial cars after the ramp became too steep for tractors and fresnos and consequently was not as thoroughly rolled as was the remainder of embankment.

The quantities of major items were:

Earth embankment, cu. yd.	22,000
Rock excavation, cu.yd.	960
Concrete, cu.yd.	1,860
Surface stripping, sq.yd.	10,500
Reinforcing steel, tons	52

The total cost of the reservoir was about $70,000. It was constructed by the Morse-Wiley Co., Seattle, and was designed and construction supervised by the Burns & McDonnell Engineering Co., Kansas City, Mo., and Los Angeles, Calif. The city was represented on the work by Thomas W. Owen, city engineer.

Moot Questions in the Design of Lake Intakes

Notes On Existing Intakes with Reference to Depths Desirable, Frazil Ice, Intake Structure and Shore Wells

By Paul Hansen

Pearse, Greeley & Hansen, Consulting Engineers, Chicago

In the course of work connected with water projects on the Great Lakes the writer has gathered data on a number of lake intakes. Some of the data are here presented, together with a brief discussion of depth with relation to turbidity, frazil ice, and form—including the desirability of extending the intake structure above water, and the utility of shore wells. Cost figures and a few elements of design besides those already mentioned are also given.

Depth—Table I, giving sizes, lengths of intake pipe or tunnels and depths of lake-end terminals, shows a variation from 18 to 58 ft. in the depth of water at the point of intake. The question arises, what depth of water should be reached with an intake to obtain satisfactory water and to avoid intake troubles? One criterion is that the depth should be sufficient to avoid the influence of wave action, undertow and resulting turbidity. In Lake Michigan these influences probably do not extend below 40 ft. However, with prolonged inshore winds on a shallow beach containing clay the undertow tends to carry turbid water out to considerable depths, as shown by experience with some of the Chicago intakes. This turbidity is decidedly more noticeable in the water from those intakes which are at shallow depths and nearest the shore. The shallowest depths of Chicago intakes are 30 ft. and the deepest 40 feet.

Frazil Ice—Another item controlling more or less the depth to which intakes should be extended is clogging with frazil ice, sometimes incorrectly called anchor ice. This clogging occurs in the most troublesome form during very cold weather with an off-shore wind producing calm water free from floating ice. At such times spicules of ice form at the surface of the lake and are carried down by vortices to the intake openings, clogging them in a surprisingly short time. The usual means for combatting frazil ice is a bypass which permits admitting water from the distribution system to the intake pipe under pressure, thereby flushing off the accumulation of ice spicules. This method is not altogether effective, partly because it is often difficult to accumulate a sufficient volume of water for the purpose between cloggings. By extending the intake into water so deep that vortices cannot reach from the surface down to the intake level the trouble with frazil ice is avoided. A proper depth to avoid frazil ice trouble under all circumstances is not definitely known though it does not appear that many intakes give trouble at depths of 30 ft. or more. The openings in the intake have some influence upon frazil ice troubles. Intakes with larger openings are likely to produce stronger vortices than those with smaller openings. At the old waterworks in Rogers Park, now a part of the Chicago system, it is claimed that frazil ice troubles were eliminated by placing on the end of the intake a large boiler shell perforated with hundreds of ½-in. holes. In this way the water was forced to enter the intake at low velocities over a large area through small openings so that vortices of sufficient depth to carry down ice spicules could not develop.

Marquette, Mich., has an unusually deep intake—over 56 ft. One object in this case was to place the intake far from shore where the water would not be affected by phenol wastes from a charcoal by-products plant. It was thought that water at so great a depth as 56 ft. would be in the zone of stagnation, uninfluenced by the zone of seasonal turn-over. This intake failed in both of these respects. Due to undertows induced by the wind the zone of stagnation is much deeper in the Great Lakes than in small lakes. Some relief is encountered in the summer time from tastes and odors due to the fact that the warm phenol wastes tend to remain at the surface but in the winter these wastes are rapidly cooled by the atmosphere to maximum density and sink to great depths.

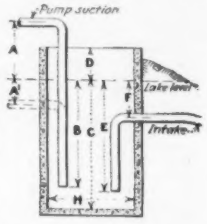
Form—Much consideration has been given to the form of intake structure. A great variety of such structures has been devised with various objects in view. One object is to obtain the water from such an elevation as not to draw in sand from the bottom of the lake. Another is to keep out fish. Still another is to protect the intake from damage by wave action and water craft. For the small installations practically all of the intakes are submerged but for tunnel intakes, as at Chicago

TABLE I—DEPTH, LENGTH AND SIZE OF PIPE OF LAKE INTAKES

Location	Size In.	Length Ft.	Depth of Water at Point of Intake Ft.
Fort Sheridan, Ill.	12	2,000	35
	16	1,500	
Highland Park, Ill.	20	3,650	
Lake Forest, Ill.	12	1,200	17
Waukegan, Ill.	24	4,000	28
Winnetka, Ill.	20	3,000	
Evanston, Ill.	42	5,600	30
Kenosha, Wis.	..	5,000	30
	12	1,100	18
	12	1,200	
Chicago cribs			
Lakeview	Tunnel	9,900	30
Wilson Ave.	Tunnel	15,840	35
C. H. Harrison	Tunnel	13,860	35
Two-Mile	Tunnel	10,560	28
Four-Mile	Tunnel	21,120	40
68th Street	Tunnel	12,500	28
Dunne	Tunnel	12,500	33
Hammond, Ind.	42	5,500	24
East Chicago, Ind.	36	3,000	20
Whiting, Ind.	66	1,600	20
Gary, Ind.	Tunnel	8,000	40
St. Joseph, Mich.	16	1,500	33
Marquette, Mich.	36	2,925	58
Muskegon, Mich.	48	7,000	48
Average excluding Chicago.		3,600	29.5
Average including Chicago.		8,900	30.5

City	Pump Suction A	A'	B	C	D	E	F	G	H
Highland Park, Ill.	....	0.13	....	14.5	5.52	....	5.05	....	16.0
Winnetka, Ill.	....	8.5	25.5	28.0	6.1	25.5	9.4	....	23.0
Racine, Wis.	13.0	....	10.0	12.2	9.3	11.9	Above —1.4	45.0	14.0
Evanston, Ill.	....	....	....	16.0	14.0	....	13.0	....	30.0
Escanaba, Mich.	9.0	5.9	9.0	12.0	9.0	10.0	19.0	50.0	30.0
Muskegon, Mich.	....	....	....	....	....	....	15.0	....	31.0
Sheboygan, Wis.	....	1.5	19.0	24.0	10.0	20.5	6.3	46.0	20.0
No. Chicago, Ill.	....	....	....	25.0	5.0	....	....	....	27.0
East Chicago, Ind.	....	....	....	24.3		....	....	....	19.5
						8.8	1.0		
Lake Forest, Ill.	....	....	....	10.5	10.3	6.0	3.0	17.0	5x18
South Haven, Mich.	6.8	8.9	10.4	14.8	7.8	7.6	7.6	23.0	12.0

DIMENSIONS IN FEET OF 11 INTAKE SHORE WELLS



and the other large lake cities, an intake structure is built extending above the water level and provided with gates and screens.

If intakes are placed at a reasonable depth it is questionable if any special form of intake structure is needed. At Marquette, for example, the intake consists merely of three upturned elbows without any special form of support. Apparently these elbows have not been disturbed in any way and do not admit sand. Many intakes give a great deal of trouble on account of the entrance of sand, but it is probable that most of this sand enters through defective joints in the intake pipe rather than through the intake structure. Generally speaking, the intakes on the east side of Lake Michigan give more trouble from the entrance of sand than those on the west side, probably due to the tendency of sand to accumulate more on that side of the lake as the result of prevailing winds.

Shore Well—A characteristic feature of the lake intakes is a shore well. The drawing and table indicate some of the dimensions of such wells. No doubt the original purposes of these wells were to provide (1) a sand trap, (2) a place where fish screens might be placed, and (3) a surge chamber for the pump suctions. It is questionable, in some cases at least, whether an intake well is needed. In fact, an intake well decreases the capacity of the intake even when the maximum feasible siphon action of a down-turned inlet pipe is utilized. At South Haven, for example, where the intake pipe tends to fill with sand, due apparently to defective joints, it has been found that an adequate volume of water with but little more sand can be obtained more readily by pumping directly from the intake pipe than by pumping from the intake well. The intake well has been used recently as a receptacle for sand when flushing out the intake. This flushing is accomplished by pumping the intake well nearly dry then suddenly opening a valve on the intake line so as to cause the sand and water to flow out with a rush. At Lake Forest it was found that with centrifugal pumps more water and better pumping conditions could be obtained by connecting the pumps directly with the intake. Pumping conditions were further improved by installing a small rotary air pump of the Nash type for keeping air out of the intake pipe. This permitted a suction lift of approximately 25 ft. In cases where the water is filtered and centrifugal pumps are used it is quite probable that intake wells can be omitted in most instances without resulting in any difficulties of operation.

Table II gives a few data on construction methods and unit costs of intakes. An attempt has been made to bring these costs up to 1924 price levels on the basis of index figures issued by the U. S. Bureau of Labor.

TABLE II—COST OF LAKE INTAKES

Location	Construction Method	Size, In.	Year Built	Cost per Foot* Original	Cost per Foot* 1924 Price Basis
Waukegan, Ill.	In trench	24	1894	$7.00	$16.00
		36	1914	16.67	29.50
Sandusky, Ohio	Trench covered with stone	42	1915	34.60	.....
Marquette, Mich.	On bottom	42	1901	13.60	25.50
	Riprap	36	1911	21.40	36.00
Bay City, Mich.	In trench	42	1900	12.10	21.50
Evanston, Ill.	On bottom	36	1901	14.90	28.00
		42			
East Chicago, Ind.	On bottom	36	1903	13.83	25.50
Kenosha, Wis.	In trench	24	1907	9.81	14.50
S. Milwaukee, Wis.		18	1907	6.80	10.00
		24	1909	14.00	23.50
Muskegon, Mich.	In trench	48	1912	14.00	22.80

* Based on Bureau of Labor price index for metal, metal products and building materials.

Building Cellular Wall Cofferdam, St. Louis Intake

Thirty Cells of Steel Sheetpiling With Clear Wall Height of 44 Ft. Built to Inclose Intake Emplacement

BY JOHN C. PRITCHARD
Director of Public Utilities, St. Louis, Mo.

Cofferdam construction and excavation for the emplacement of the new St. Louis water-works intake at Howard Bend on the Missouri River are described below. River control to develop deep water at the intake was described in "Engineering News-Record" April 8, 1926, p. 570. A succeeding article will describe driving and sealing concrete piles under water.—EDITOR.

LOCATED on the river shore where rock is 92 ft. deep, and partly inshore and partly in the river, the new intake for St. Louis water-works presented a construction problem of magnitude. Fig. 1 is a plan of the structures the overall dimensions of which are 100x125 ft. The elevation of the river bank is about 42. Extreme low water was assumed at El. 11, and extreme high water at El. 43. So that the low service centrifugal pumps might be always under head, the bottom of the low service pit was made El. 0.5. Due to the extreme height of high water with its consequent buoyant effect, it was deemed necessary to put at least 10 ft. of concrete below the pump pit floor. This involved excavating to a depth of about El. —10. In addition to this necessary depth, 4 ft. were allowed for displacement of concrete foundation piles, so excavation was carried to an ultimate depth of —14. To reduce the depth of the cofferdam, the entire site was excavated to El. 30, from which elevation the cofferdam was started, excavation going 44 ft. below this level.

In view of the large dimensions and the depth of excavation, a single line of sheetpiling with its necessarily very heavy bracing, was considered out of the question. A cellular cofferdam was adopted consisting of 30 closed cells. At the junction of each pair of cells there was a special three-way Y-pile, which interlocked with the segmental walls of the cells and with a diaphragm, Fig. 2, connecting front and back walls. Due to the unusual shape of the intake, the cells varied in size and shape, there being in all about 1,666 piles, including corner piles. Steel piles weighing about 38 lb. per foot and 56 ft. long were used. Driving these

piles to El. 30, and pumping out the sand to El. —14 left a penetration of about 12 ft.

Assembling Cells—The plan of construction was to assemble and close several complete cells before attempting to drive. A 30-ton locomotive crane was moved down into the hole on a standard-gage track which connected up with the water-works switch from the Rock Island R.R. The storage pile of sheeting was located close to the edge of the hole, so that piles could be snaked down to the crane by two teams. The crane, Fig. 3, had a special 100-ft. boom, which stood at a clearance of about 96 ft. above the ground, and which handled and interlocked the 56-ft. piles. This boom also carried a 2-in. jet pipe, with water at about 80-lb. pressure, for jetting down the piles.

In laying out the cells, the corner piles were staked out first from a center stake, at their theoretical location, which eliminated cumulative error due to gain or loss of distance in assembly. After assembling several cells, it was found that the piles in the curved inner and outer walls were losing so much distance in the interlock that it was not possible to drive them to the theoretical curve, and it was necessary to put one extra pile in each outer wall to bring the corner pile to its theoretical location. At this juncture, 3-in. pieces were cut from a number of piles, and upon starting to assemble a cell, these were laid out on the ground, pushed up tight together, to an even curve that fitted between corners. A templet was then set to fit this curve, and assembling commenced.

The usual procedure was to assemble the inner, or shorter, wall first, then the diaphragm including both corner piles. The curve being located and the templet fitted for the outer wall, assembly then proceeded from the last cell assembled toward the corner pile just placed. As the piles neared closure, the distance was frequently checked with the short pieces of pile. When the assembly had reached about four piles from the diaphragm and corner pile just set, a pile was interlocked with this corner pile, the closing pile being usually four piles out from the diaphragm of the cell under assembly. In assembling, each pile was simply interlocked with the last pile, and allowed to rest on the ground. The jet was then started,

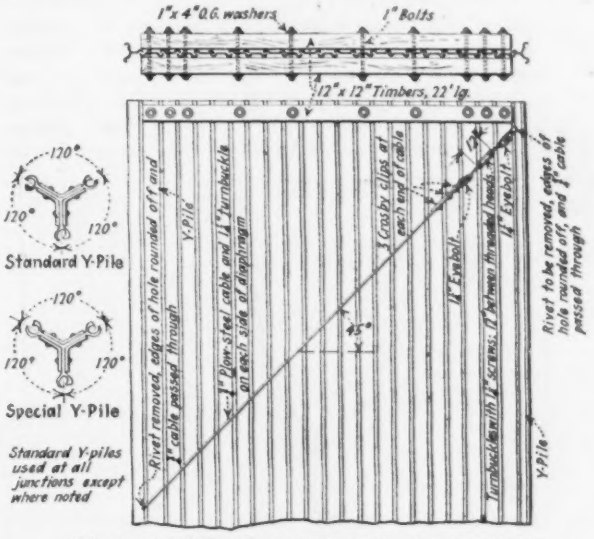

1" x 4" O.G. washers
1" Bolts
12" x 12" Timbers, 22' lg.
120°
Standard Y-Pile
Special Y-Pile
Standard Y-piles used at all junctions except where noted
Y-Pile
Rivet removed, edges of hole rounded off and 1" cable passed through
1" Bolt
1" Turnbuckle
Rivet to be removed, edges of hole rounded off, and 1" cable passed through
45°

FIG. 2—DETAIL OF DIAPHRAGM AND Y-PILES

and with the aid of a little churning up and down, the pile penetrated about 15 ft. before putting on the driver.

Driving Sheetpiles in Cells—Driving the piles to El. 30 was started after three cells had been completely assembled and closed. The contractor attempted to drive this sheeting with a No. 1 Vulcan hammer, in swinging leads, handled by a 30-ton crane with a 70-ft. boom. This crane also carried a 2-in. jet with water at about 80-lb. pressure. The Vulcan is a heavy, slow stroke hammer, and the swinging leads made it almost impossible to center it over the piles. After driving about one cell with great difficulty with this hammer, it was discarded and a No. 6 McKiernan-Terry hammer, weighing 2,900 lb., with a very rapid stroke, was substituted. This hammer was light and easy to handle with the crane. From this time on, there was no particular difficulty; and it was even possible to drive faster than the piles could be assembled. The record for assembling was 44 piles in a ten-hour shift, while in one shift 85 piles were driven about 42 ft. each. All piles were jetted during driving.

A continuous track was built around the cofferdam on top of the driven cells, so that a crane could travel all around the hole. Assembling was started Sept. 1, 1924, and the closing pile was driven Dec. 15, 1924. Fig. 3 gives an excellent idea of the layout and

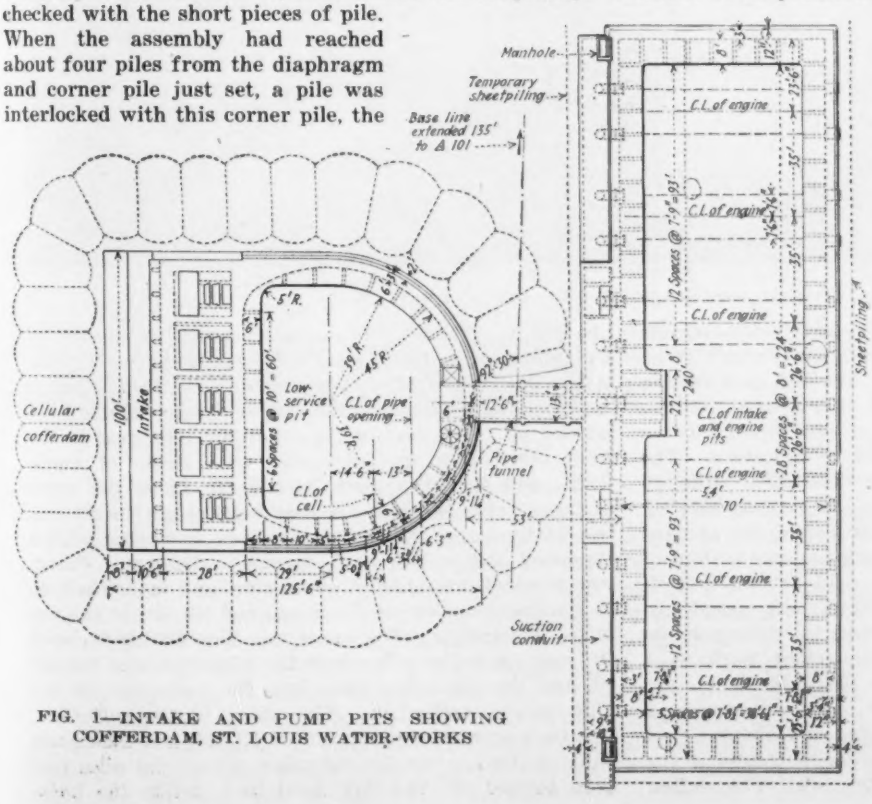


FIG. 1—INTAKE AND PUMP PITS SHOWING COFFERDAM, ST. LOUIS WATER-WORKS

operation of the two cranes, the crane on the left with the long boom being the assembling crane, with the driver in action at the right of the picture. In all, the cofferdam contained 1,666 piles, which was four more than the plan called for.

Dredging Cofferdam—Of the 30 cells in the cofferdam, 18 were on land and 12 were in the river. While driving was in progress, a dredge had been fitted up, consisting of a barge about 60x24x4½ ft. with a 125-hp. boiler and a direct-driven 10-in. centrifugal pump. When there remained some three or four river cells to assemble, this dredge was floated inside the cofferdam and put to work (see Fig. 3). The suction was a 10-in. pipe, with an ell and extension funnel-shaped suction piece on the end. No cutting device was used, but the suction was equipped with two 3-in. jets connected to a pump on the barge, which served as agitators. The material dredged was a very fine blue sand, although several strata of tough blue clay were encountered. The clay was not easy to handle, and came out in hard lumps. After about six weeks' dredging, the bottom of the excavation reached about El. —14 around Feb. 1, 1925. During the later concrete piledriving operations, the dredge remained in the cofferdam furnishing steam for the pile hammer. It did no further work as a dredge except for trimming off a few high spots.

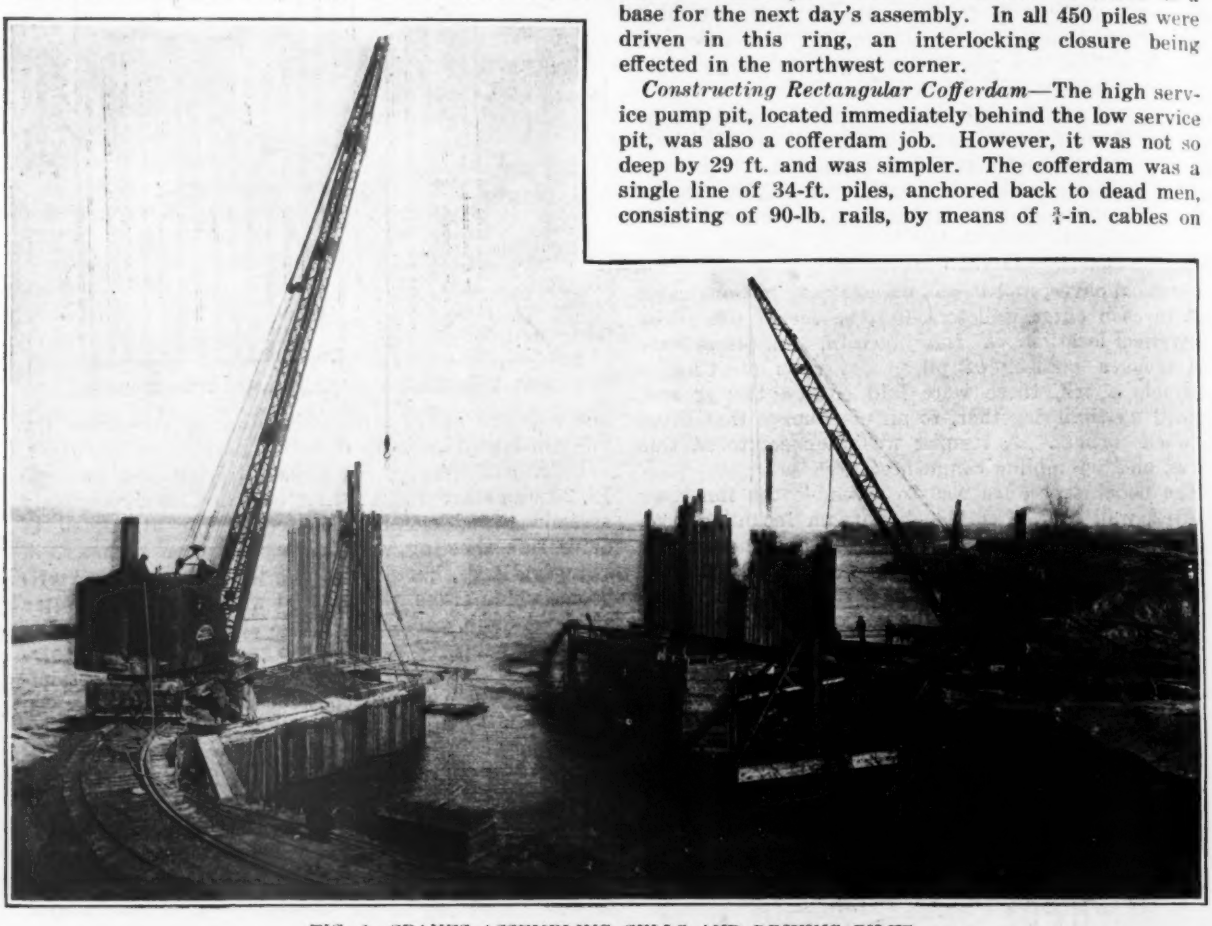


FIG. 3—CRANES ASSEMBLING CELLS AND DRIVING PILES

Driving Inner Ring Sheeting—After dredging, a closed ring of sheetpiling 48 ft. long and about a foot inside the outside wall line of the lowest course of the intake and pit wall was driven to rock. This piling came to rest with the top at about El. —4, which meant that it projected through the concrete seal and into the concrete bottom of the pit. As in the case of the cofferdam, these piles were assembled first and then driven. After the first pile was given a penetration of about 8 ft., the next piles were interlocked and given an equal penetration by a little churning up and down. When about 50 piles had been assembled, driving commenced, using a No. 9*B* McKiernan-Terry submarine pile hammer, weighing 6,450 lb. No jet was used. About a dozen piles were left undriven to serve as a base for the next day's assembly. In all 450 piles were driven in this ring, an interlocking closure being effected in the northwest corner.

Constructing Rectangular Cofferdam—The high service pump pit, located immediately behind the low service pit, was also a cofferdam job. However, it was not so deep by 29 ft. and was simpler. The cofferdam was a single line of 34-ft. piles, anchored back to dead men, consisting of 90-lb. rails, by means of ¾-in. cables on about 7-ft. centers. The side nearest the low service pit was connected to the cellular cofferdam with two T-piles. After completing piledriving in the low service pit, it was necessary to move the driver barge to the high service pit. The clay in the cofferdam cells next to the high service pit was excavated to a depth of about 3 ft., and the piles were burned off about the same distance from the top. A hole big enough to contain the dredge barge had previously been excavated with a clamshell inside the high service cofferdam. Water was pumped into the low service pit and into this hole in the high service pit till it reached El. 30, or the top of the sheetpiling. The barge was then floated through the opening in the cells where the piles had been burned off and the clay excavated, into the excavator in the high service cofferdam. The water in the cofferdam was then pumped down to about El. 26, and bulkheads built in the low service cofferdam where the piles had been burned off, the clay filled back inside the bulk-

heads, and the operating track again built over the cells. The dredge immediately started to work pumping the sand out of the high service pit, which operation was completed about June 25, 1924.

Organization—The intake structures were designed in the Supply and Purifying Section of the St. Louis Water Division, C. M. Daily being at that time division engineer, and Edward E. Wall, water commissioner. The writer was resident engineer from June 1, 1924, to May 15, 1925, being succeeded by J. B. Dean. The Frazier-Davis Construction Co. is the contractor, with F. R. Wiederholdt as general superintendent, assisted by C. W. Gove and Henry Snowden.

"Multiple-Dome" Design Adopted for Coolidge Dam

Structure of Novel Type and Unusual Proportions Selected for Regulation of Gila River and Irrigation Supply

TWO weeks ago the Secretary of the Interior approved a special report of a board of consulting engineers recommending adoption of the "multiple-dome" design for the Coolidge dam across the Gila River near the San Carlos Indian Reservation, in Arizona. A project for an irrigation and flood conservation dam in the San Carlos region has long been before the Interior Department. Congress made an initial appropriation for construction two years ago, thereby approving the execution of the project. Since then the development of the project has been under way.

A storage of about 1,300,000 acre-ft. of water is to be provided, to irrigate an area of some 100,000 acres of land near Florence and Casa Grande, Ariz., and control flashy floods which may reach a flow exceeding 100,000 sec.-ft. At the site selected, the valley of the Gila is a rock trough about 250 ft. deep and about 600 ft. wide, with a shallow fill of river soil in the bottom.

Plans for the dam were prepared in the Los Angeles

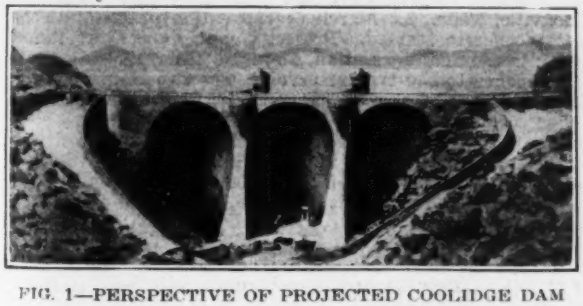


FIG. 1—PERSPECTIVE OF PROJECTED COOLIDGE DAM

office of the U. S. Indian Service, under the direction of Major C. R. Olberg, assistant chief engineer, Irrigation Bureau of the Indian Service. The design was for a structure comprising three arched spans of about 180 ft., with maximum height 250 ft., supported by two buttresses in the valley bottom and the hillside abutments.

A year ago the Commissioner of Indian Affairs appointed L. C. Hill and F. A. Noetzli, of Los Angeles, as consulting engineers to advise on plans and construction. Designs were thereupon prepared for dams of the gravity, arch, multiple-arch, multiple-dome, and rock-fill types. Based upon these, the engineers recommended last fall that bids be asked for the construction of dams of the gravity, multiple-arch, and multiple-dome types, and that the final selection of type of dam be made after receiving bids upon these. Recently the Commissioner of Indian Affairs recommended construction of the multiple-dome type without first calling for competitive bids. A further review of the plans was then undertaken, at the direction of the Secretary of the Interior, by Maj. Gen. W. C. Langfitt and A. J. Wiley, as a board of experts. This board examined the plans

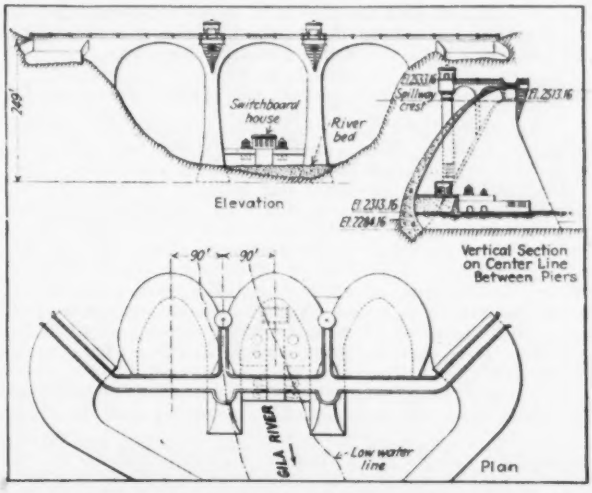


FIG. 2—MULTIPLE-DOME DESIGN FOR COOLIDGE DAM, GILA RIVER, ARIZ.

and the site, and recommended approval of the multiple-dome plan, endorsing, with minor modifications, the plans as prepared in the bureau. It also recommended that a power plant be constructed and equipped as part of the dam project to develop the available energy of the stored water. An adequate market for the power is at hand, at profitable rates, and the power revenues will relieve materially the operation and maintenance charges to the water users. This report was approved by the Secretary of the Interior on May 10.

As may be seen from the attached reproduction of the preliminary plan, the design differs from the ordinary multiple-arch design in the magnitude of its arch spans and in the doming of the arches in the vertical plane. Spillways are provided in the abutment sections, away from the dome structures, which have a freeboard of 20 ft. above spillway crest.

Final plans are now being prepared with a view to beginning construction without delay.

Water Power Resources of the Rogue River

The potential power of the Rogue River in Oregon and its principal tributaries under natural flow is 514,000 hp. for 50 per cent of the time, and 202,000 hp. for 90 per cent of the time, and by the construction of four storage reservoirs this power could be increased to 532,000 and 429,000 hp., respectively, according to a report recently issued by the U. S. Geological Survey. There are eight water power plants in the basin, with a combined capacity of only 13,000 hp., 28 undeveloped power sites and four undeveloped reservoir sites. The Rogue River and its tributaries have a large underground flow which contribute to their regularity.

What Is Being Done in the Major Water Supplies

Brief Reviews of the Progress Being Made in the Water-Works Improvements in the Principal Cities and Districts in the United States

Outcome at Boston Uncertain

Long controversy over an additional water supply for the Boston Metropolitan District and the city of Worcester continues. After a compromise between Goodnough plan of 1922 and Gow plan of 1926, mayor of Boston interjected report from John R. Freeman, advising modification of Gow plan. Fate of bill in legislature uncertain.

Providence Spending $21,000,000

On the $21,000,000 project for a new water supply from the Scituate River, about $18,000,000 has been expended or will be required on unfinished contracts. The 37,000-m.g. Scituate reservoir has filled to 60 per cent of its capacity. The seven-mile aqueduct, including 3½ miles of tunnel, is practically completed. Part of the rapid filtration plant will go into use this summer and the rest by the end of this year. This plant is of 50-m.g.d. capacity, with influent and effluent aeration and large open coagulation basins; to extend it to its ultimate capacity of about 100 m.g.d. additions to the filters and effluent aerator only will be required. It is expected that contracts will be let during the summer for a 38- and a 12-m.g.d. reinforced-concrete covered distributing reservoir, and seven miles 40 to 60-in. connecting pipe. Project probably completed early in 1928.

Catskill System Essentially Completed

Stream-control conduit through Gilboa dam being closed. The 20,000-m.g. Schoharie reservoir, formed by this dam, will go into service this summer, marking the essential completion of Catskill system. Reservoir will regulate flow of Schoharie Creek through 600-m.g.d. Shandaken tunnel, completed in 1924. New 72-in. steel conduit in Brooklyn, to be completed about end of 1926, will serve as one of the main distributors of Catskill water brought to Brooklyn through deep pressure tunnel. Plans for second deep tunnel, about 20 miles long and for the most part 17 ft. in diameter, still before the Board of Estimate.

New Jersey Metropolitan District

Dams of 27,000-m.g.d. Wanaque reservoir for North Jersey Water District 75 per cent completed and 105-m.g.d. Great Notch tunnel practically done. Expected that remainder of aqueduct—150-m.g.d. capacity north of Passaic River and 97-m.g.d. south of tunnel—will be contracted for this summer, as also West Brook viaduct across the Wanaque reservoir—including a 600-ft. concrete girder structure—and the clearing and grubbing of the reservoir site. Among the eight participants in the Wanaque district are Newark, Paterson, Passaic and Kearny. Special session of state legislature opens June 22 to act on recommendations of State Water Policy Commission.

Rochester Surveys

Surveys of various possible sources of supply are being made to find the best one for at least doubling the present capacity of 30 m.g.d. Allen Hazen and H. P. Eddy are advisory engineers on the preliminary work.

Buffalo Filters Nearly Completed

Treatment plant (160-m.g.d.) and low-lift pumping station nearly complete. To provide better pressure for high ground in northeastern part of city, two 1,200-g.p.m. electric-driven centrifugal pumps will be installed to lift water to a 0.25-m.g. tank supported on concrete and inclosed with an ornamental concrete shell.—Western New York Water Co. building 1-m.g. elevated tank.

Philadelphia Improving Existing Works

Philadelphia has done nothing toward carrying out either of two proposed plans for large additions to water supply. Rebuilding Torresdale pre-filters well along; constructing new intake and adding pumping units at same point. Two new booster pumping stations will soon go into service; interconnections between the various sources of supply are being improved. New Fairmont dam on Schuylkill River nearly completed.

Baltimore Making Extensive Improvements

New 112-m.g.d. wood-slat-bottom filter plant close by old 128-m.g.d. filters will soon be completed, at cost of $2,780,000. Electrification of Mt. Royal pumping station will cost $150,000. About 100 miles of 6- to 60-in. mains will be laid this year. Surveys being made on Prettyboy impounding project; a 2,000-m.g. reservoir, formed by a dam 120-ft. high, with a 200-ft. ogee spillway and a 700-ft. bridge over top of dam; $3,000,000 allotted.

Additional Conduit and Filters for Washington

Washington's new 100-m.g.d. conduit is in use. Two high-service reservoirs and first high-service pipe line completed; second and third pipe lines over 50 per cent complete; new 80-m.g.d. filters will be completed in July, 1927.

Atlanta Intake and Mixing Basin

Atlanta, Ga., is building 60-in. intake conduit at Chattahoochee River pumping station; $140,000 concrete mixing basin and brick chemical house at filtration plant; planning two 30-in. and a 24-in. supply main, at estimated cost of $500,000. These mains and intake are force account work.

Activities at One Florida City

As an illustration of the extensive water-works construction in Florida, Tampa recently put in use 15-m.g.d. pumping station six miles distant on Hillsboro River, and two 5-m.g.d. fire pumps at its old 16-m.g.d. well-supply station, which will be held in reserve. Two 0.5-m.g. tanks have been erected and a third is proposed.

Knoxville Additions Under Way

Major contracts for new $1,250,000 water-works for Knoxville, Tenn., let March 6; excavation practically complete; concrete started. Project comprises a short tunnel and intake pumping station, 15-m.g.d. filters, 10-m.g. reinforced-concrete box-type reservoir. The two 15-m.g.d. high-lift pumps are of steam-turbine centrifugal type operating under 350-ft. head with turbines driving also electric generators supplying the two 18-m.g.d. low-lift motor-driven centrifugals under 50 ft. head. High-lift units have guaranteed duty of 200 m. ft.-lb. per 1,000 lb. of steam. Pumping equipment contract is $120,000. Two 500-hp. boilers with stokers will furnish steam at 300 lb. pressure and 200 deg. superheat.

Progress at Nashville

Nashville, Tenn., spending $2,000,000 for improvements. Work under way on 12,000 ft. of 36-in. cast-iron force main, 17,000 ft. of 16-in. and 9,000 ft. of 12-in. high-service mains, a 2-m.g. high-service reservoir and a 2-m.g., $435,000 high-service booster station, $100,000 boiler house containing three 500-hp. boilers and equipment costing $116,000, all to be completed this year. Contracts will be let before Jan. 1 for a 28-m.g.d. filter and for covering the 52-m.g. Kirkpatrick Hill reservoir; cost, $1,000,000.

Additional Indianapolis Filters in Use

In March the Indianapolis Water Co. put into service its new 12-m.g.d. filter plant and two 6-m.g.d. motor-driven centrifugal pumps for high service. Contracts have been let for a 6-m.g.d. reinforced-concrete reservoir at the Fall Creek station.

Detroit Adds 300 Miles of Pipe

Detroit will add 300 miles of water pipes to the distribution system this year. In addition, proposals for construction of first sections of new project will be asked for soon. Project includes an intake in Detroit River, 10 miles of tunnel, 14 ft. and 12 ft. in diameter, a low-lift pumping station, filtration plant, and 220-m.g.d. distribution pumping station. Several large elevated water tanks and a motor-driven booster station will be constructed.

World's Largest Pumping Station

Work on the 300-m.g.d. Western Avenue station, Chicago, is about 60 per cent completed. It is expected that it will be in use in summer of 1927 (see article on p. 858). Other large work well under way is the Chicago Ave. tunnel, which is a 4,900-ft. extension of 16-ft. tunnel from Two-Mile Crib to a proposed crib opposite Carter Harrison crib, and 11,000-ft. of 13-ft. tunnel to the Chicago Ave. pumping station. Crib will be started next spring and completed in 1928. Last year a 10-year program of universal metering was initiated but progress in getting under way has been slow due to labor conditions.

Completing St. Paul's Five-Year Program

St. Paul is building a 90-in. concrete conduit, 23,400 ft. long, between Vadnais Lake and the 42-m.g.d. filtration plant. This completes $5,500,000 program started in 1920 consisting of filters, a 16- and an 18-m.g. reservoir, one pumping station for distribution system and one to raise Mississippi River to a chain of small lakes, a 60-in. conduit 43,500 ft. long—8,000 ft. of steel and 35,500 ft. of concrete.

St. Louis Howard Bend Plant

The $1,060,000 contract for the intake and engine pits of the new Howard Bend plant for St. Louis will be finished this summer. Sixteen miles of steel pipe connecting filters with Stacy Park reservoir and thence with city will be ready Aug. 1. The $1,160,000 Stacy reservoir is about 20 per cent along and will be completed in about a year; also the $715,000 filter plant contract, let in February. Contracts for boiler house and equipment for Howard Bend plant are either let or about to be let. Contracts for three low-service steam-turbine-driven centrifugals and two high-service centrifugals will be let early in August under $650,000 appropriation. Plans under way for settling basins, grit chamber and mixing chamber costing $1,000,000; to be let after October.

Completion Percentages at Kansas City

Percentages of completion of main contracts for new Kansas City water-works are: Missouri Valley $1,360,000 tunnel, 21 per cent; Turkey Creek, $850,000 tunnel, 70; East Bottoms $710,000 station, 90; $550,000 steel pipe lines, 81; $2,050,000 settling basins, 49; $1,300,000 filtration plant, 58; $250,000 intake, 68; $280,000 valves and cast-iron pipe, 90; average, 55 per cent. Completion expected early in 1928.

Garza Dam at Dallas Nearly Done

A hydraulic-fill dam, 80 ft. high, 2 miles long, of which 3,500 ft. is across main valley, on Elm Fork of Trinity River (26 airline miles from Dallas) is being built at a cost of $5,000,000 to impound 63,000 m.g. from a drainage area of 1,110 sq.miles. Service spillway is concrete, ogee type, 560 ft. long, and will discharge 78,000 sec.-ft., with emergency spillway capacity of 135,000 sec.-ft. Embankment contains 2,000,000 cu.yd. Construction started Oct. 3, 1924, and will probably be completed Sept. 1, 1926.

Completed and Projected Work at Denver

Denver, Colo., has just completed a $7,500,000 three-year program involving: A 70-m.g.d. filter and 23 miles of conduits—5 miles of 54-in. concrete, 10 of 66-in. wood-stave, 6 of concrete and 2¾ miles of 54- and 48-in. steel; 100 miles of distributing mains; five centrifugal pumps aggregating 49-m.g.d. capacity in three stations. A survey and budget of $7,500,000 for coming six years' needs, under compilation includes: 24 miles of conduit (13 of 66-in., 7½ of 40-in. and 2½ miles of 108-in. steel), reconstruction of Lake Cheesman outlet system and of Kassler slow sand filters, Capitol Hill pumping station and reservoirs; and $2,250,000 distribution extensions. Consummation of plans for use of Fraser River water to be brought through Moffat tunnel and for additional storage on South Platte River has been postponed by the resignation of a majority of the water board because of differences over policies.

Additions to Seattle Works

In the development of Lake Youngs as a storage reservoir for Seattle, Wash., two earth-fill dams have been built which will raise the lake level about 20 ft. and provide a usable storage of about 4,000 m.g.; an 8-ft. concrete-lined outlet tunnel, 11,000 ft. long, has been completed. A 10-mile gravity aqueduct from Cedar River to Lake Youngs is proposed. A 54-in. steel pipe line 5 miles long is to be constructed from the existing Cedar River pipe lines to reservoirs in the north end of the city. To serve higher levels there are being provided two 1-m.g. standpipes and two 2,000-g.p.m. pumps driven by 300-hp. motors, each operating under 270-ft. total lift. Some 3 miles of 30-in. cast-iron pipe are being added to low-level distribution system and similar extension is projected. Cost, $4,000,000.

Tacoma Spending $1,000,000

The 1926 program of Tacoma, Wash., includes $1,000,000 of work: 25-m.g. reservoir, 5 miles from city; 1-m.g. standpipe in city; 34- or 36-in. pipe line connecting reservoir and standpipe; 30-in. conduit from reservoir to Puget Sound; 10-m.g.d. electrically operated pumping plant; reinforcement of distribution system.

More Reservoirs for Portland, Ore.

A new 40-in. steel pipe line about 4¼ miles long is being built by Portland, Ore., from Mt. Tabor reservoir No. 5 to the Vernon district. The city plans to build the first 100-m.g. unit of 500-m.g. storage near the city in the immediate future. Core drillings completed at site Bear Creek dam on Bull Run River; contract to be let this fall for dam and clearing the site of 11,000-m.g. reservoir.

Hetch-Hetchy Progress

Preliminary work on the San Joaquin section of Hetch Hetchy aqueduct is going forward under $10,000,000 bond issue voted by San Francisco late in 1924. A bond issue of $23,000,000 to complete this aqueduct is to be asked for about three years hence. Of portions of the aqueduct already completed, a mountain section supplies a city hydro-electric plant and the bay section is rented to the Spring Valley Water Co. Company completing Calaveras dam.

Good Progress on East Bay Project

The Mokelumne River project for an ultimate 200-m.g.d. supply through a 90-mile conduit to Oakland and other California cities in the East Bay Municipal Utilities District is well along in the 42-mile section between the district and San Joaquin River, from which an emergency supply may be taken. (See also p. 874.)

Los Angeles Reaching Out for Colorado River

Completion of St. Francis dam adds 38,000 acre-ft. to capacity of Los Angeles aqueduct storage system, which now comprises twelve reservoirs holding 155,000 acre-ft. or some 30,000 m.g. Chief Engineer William Mulholland points out that all the city's present sources developed to their utmost can be depended upon to produce only 450 sec.-ft. (300 m.g.d.). Out of the last ten years in only two has there been a supply greater than this. Last year for a three-month period domestic consumption averaged 146 m.g.d. and peak day was 205 m.g.d. Bond issues totalling $2,100,000 for proposed Colorado River aqueduct were voted in 1924 and 1925. When survey crews come in off the desert for the summer it is expected that sufficient topography will have been taken to make up relief maps of the several locations which have been considered as possible routes for bringing a 1,500 sec.-ft. supply from the Colorado River to the city of Los Angeles. Roads and camps have been built and contract let for excavation along river where it is proposed to have an infiltration canal.

New Methods in the Water-Works Field

What the Engineer Has Developed in New Equipment and Practices

Laying 54-In. Main Across Mississippi River at Minneapolis

By John A. Jensen
Superintendent, Water Works Department, Minneapolis, Minn.

During 1924-25 the Minneapolis Water Department laid a new line of 50- and 54-in. steel riveted pipe to connect the new Fridley filtration plant with one of the existing supply mains. After leaving the header chamber at the pumping station, the 54-in. portion of the line crosses the Mississippi River, which at this point is about 700 ft. wide and 4 to 7 ft. deep. The elevation of the water was approximately 89 city datum and the center of the pipe when laid varies from 82 at the west end to 80 at the east end. The pipe was of ¼-in. riveted steel and was delivered in 30-ft. lengths.

PULLING 30-FT. SECTION OF 54-IN. PIPE INTO PLACE

A gradually sloping skidway of 28-in. I-beams laid flat was constructed on the west side of the river with a shallow pit for the boiler makers. The lower end of the skid extended into the water. A dipper dredge was employed to cut a trench for the pipe. The blue clay and mixture of sand and clay satisfactorily withstood current action.

In installing the pipe in the trenches, the front end pipe was closed with a torpedo cone head with shackles for the cables. A hoisting engine was set up on the east side of the river and a six-part line rigged up to take up on the main cable, which was played out in the trench to the farther side of the river. As succeeding sections of pipe were added, the pipe was pulled into the river 30 ft. to the pull. The front end was ballasted by water to keep it well below the current influence, but without dragging hard on the bottom. When the line nearly reached final position the blue clay gave so much resistance that another pulling engine was necessary, but the pipe was finally placed without undue difficulty. The west end was lowered by special tackle, with the assistance of water ballast. After connecting the shore elbow, the end of the pipe was brought above the surface. The east end being straight was included in a shore cofferdam, within which the torpedo head was cut off and connection made to the shore pipe.

Instead of using pile anchorages, the pipe is being unwatered in sections and covered with a concrete shell both to overcome buoyancy when empty and to serve as an exterior protection under water.

The length of the crossing was 743.9 ft. The labor costs were: Dredging, $528; line piling, $665.35; riveting and placing pipe, $6,136.86; labor overhead, $320.05. The total cost was $7,650.26, or $10.28 per lineal foot.

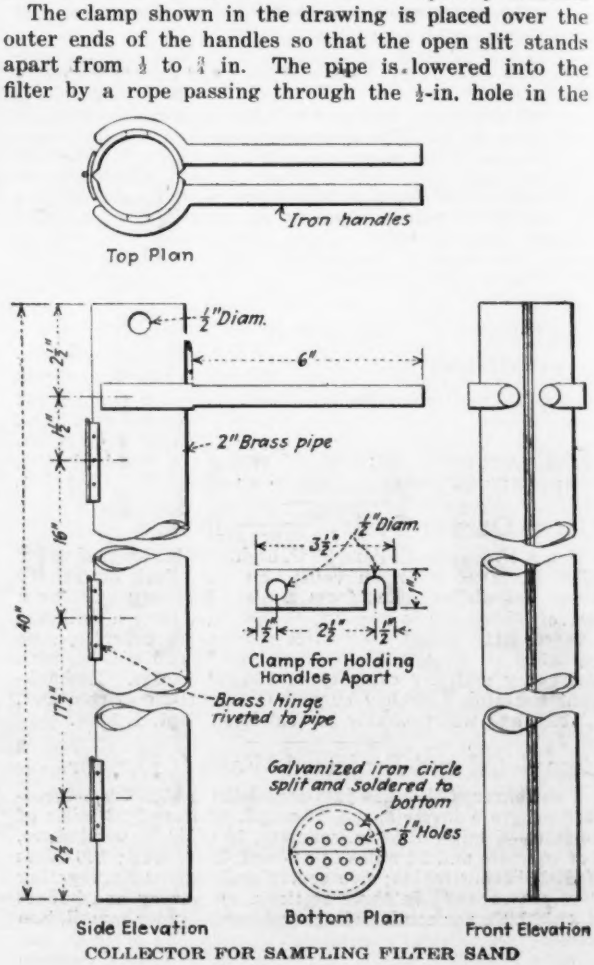
New Collector for Sampling of Filter Sand

By August V. Graf
Chief Chemical Engineer, St. Louis Water-Works

There are a number of methods that may be used in collecting sand samples from rapid sand filters for sieve analyses, but the method described here has been found best to obtain a representative sample since it eliminates the possibility of mixture of the upper layer of sand with the lower layers.

The collector is a 2-in. split and hinged brass pipe, which is lowered vertically into the filter bed during washing and is then withdrawn after the wash-water has been shut off and the sand bed completely drained.

The clamp shown in the drawing is placed over the outer ends of the handles so that the open slit stands apart from ½ to ¾ in. The pipe is lowered into the filter by a rope passing through the ½-in. hole in the



COLLECTOR FOR SAMPLING FILTER SAND

top of the pipe. The lowering should not begin until after the full rate of the wash-water in the filter has been attained and then should continue very slowly, the time of lowering to be fully 30 sec. After allowing the pipe to remain standing on the gravel bed for several minutes, the wash-water should be shut off slowly and the sand bed drained. It is very important that this be done before proceeding.

The clamp can now be released and the handles brought together closing the split in the pipe. Care should be taken not to exert too much pressure as the sand will tend to rise in the pipe, thus elongating the sample. After withdrawing, the split pipe may be laid out opened on a table, the excess sand from each half of the pipe trimmed off and two samples of filter sand of known volume obtained.

The collector was designed by John Allgeyer, superintendent of the Chain of Rocks filter plant for St. Louis.

Substitute Surface for Jet Condensers at Ward Station, Buffalo

By S. E. Roof
Designing Engineer, Filtration Division, Bureau of Water, Buffalo, N. Y.

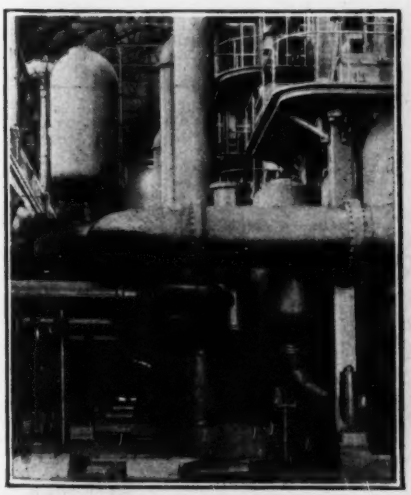
THE building of the filtration plant for the city of Buffalo, N. Y., made necessary changes in the condensing equipment of the pumps in the Col. F. G. Ward Pumping Station. The original pumping plant consisted of five vertical triple-expansion pumping engines with jet condensers fitted with attached vacuum and condensate pump, installed by the Holly Manufacturing Co. (Snow Steam Pump Works) of Buffalo, in 1912. The pumps are rated at 30 m.g.d. each and operate with steam of 250-lb. gage pressure with 100 deg. superheat. The pumps operate under two discharge heads, one of 85 and one of 45 lb. Each pump may be operated on high or low service, as the supply may demand.

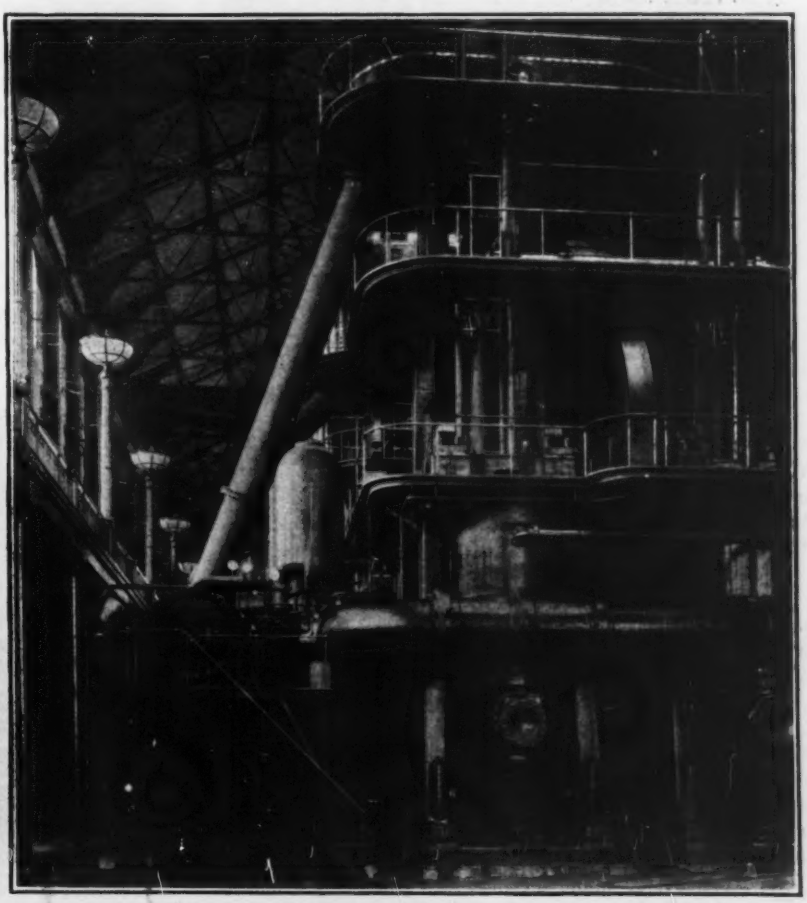
The decision was made to discard the jet condensers, as it would be necessary to use filtered water for their operation, and install water-works type surface condensers with duplicate condensate pumps, the vacuum to be maintained with two-stage steam air ejectors. The specifications called for 1,800 sq.ft. of cooling surface to be placed in the discharge line of each pump. The contract was awarded to the Worthington Pump & Machinery Corporation.

The condenser shell and tubes follow standard water-works practice with additional space for water passage around the tubes. The condensate is returned to an open feed-water heater by means of duplicate centrifugal pumps, one driven by an electrical motor and the other by a water turbine. The latter takes water from service lines at 75-lb. pressure and discharges it into the suction chamber of the main pump against a head of 15 lb., at a nominal 30-g.p.m. rate. Vacuum is maintained with a two-stage condensing steam air-ejector combined with a surface inter-cooler and after-cooler. The ejector is rated at 11 cu.ft. of air per minute.

The condensate from the main condenser is pumped through the inter- and after-cooler. The condensate from the first stage is returned to the condenser shell by a U-pipe. The condensate from the second stage is trapped into the main condenser hot well. The combined condensate of all pumps is piped to the feed-water heater. In this line are installed, in parallel, two oil filters. The condenser hot well was tapped for cold water for starting purpose. The inter- and after-cooler condenser was tapped for cold water injection.

Two of the pumping units have been equipped com-





JET CONDENSERS REPLACED BY SURFACE CONDENSERS FOR TRIPLE EXPANSION PUMPS AT BUFFALO
Left: Old Jet Condenser. Right: New Surface Condenser Substituted

plete with surface condensers and are in operation at this time. Tests have not been made to determine the efficiency of the installation, but the operators have had no difficulty in maintaining a vacuum within 1 in. of the barometer reading. It has not been found necessary to use the cold water injection in the inter- and after-cooler.

The work was designed and constructed under George C. Andrews, engineer of filtration, and the writer as designing engineer, Filtration Division, Bureau of Water. Howard H. Fitzgerald, chief engineer of the Ward Station, co-operated in the construction work.

Chart for Converting Kutter's "n" Into Hazen and Williams' "C"

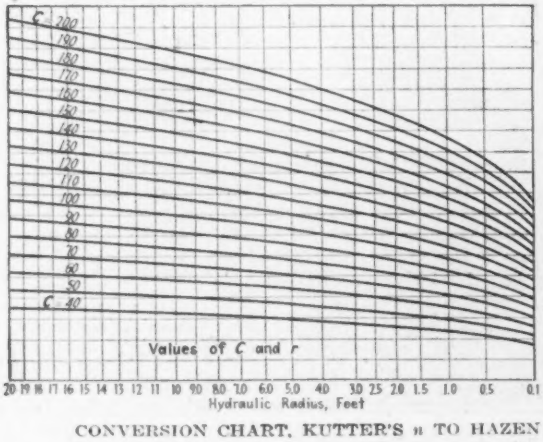
By R. De L. French and F. M. Wood
Professor of Highway and Municipal Engineering, and Lecturer in Civil Engineering, McGill University, Montreal

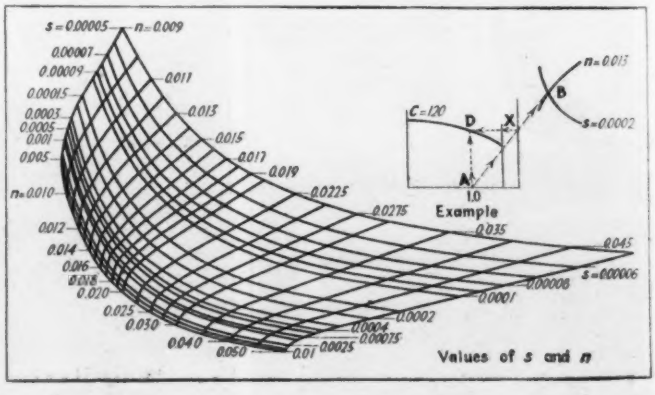
In *Engineering News-Record* of April 22, 1926, p. 653, there appears an article by J. B. Lippincott on the use of the Hazen and Williams slide rule in hydraulic computations having to do with flow in open channels. Mr. Lippincott says that possibly one of the reasons why the Hazen and Williams formula is not more popular for this purpose is that values of C in this formula, applying to open channels, are not so well known as are the values of n for the same conditions in Kutter's formula. The diagram given by Mr. Lippincott shows the approximate relation between these constants, and is no doubt useful, but it is quite possible to design a chart which will give the exact relation between them.

Owing to the fact that K in the equation $V = K\sqrt{rs}$, as determined by Kutter's formula, depends not only on n, but also on r and s, it follows that a constant value of n will give varying corresponding values of C in Hazen and Williams' formula, as r and s vary.

The accompanying chart will give values of the remaining variable when any three of the four (C, r, s and n) are known. Generally, it is desired to find C, knowing n and s. Estimate the value of r as closely as practicable. Enter the chart with this value of r along the left-hand base line, and connect the point thus found with the intersection of the proper n and s curves by a straight line. This will locate the point X on the vertical axis. Project to the left from X and upward from A. The intersection of these lines determines the value of C sought. With this value of C, and the known dimensions of the channel, as deduced from the estimated r, work out, by special slide rule or otherwise, V or Q from the Hazen and Williams formula. If V or Q as thus found does not check closely with the actual V or Q of the problem, repeat with a new value of r. Considerable variation in the assumed value of r does not greatly alter the value of C.

With a little experience the chart may be used rapidly and the computer who relies on it has the satisfaction of knowing that his results are exactly the same as would be obtained from the cumbersome Kutter formula. The chart was originated by the authors of this article.





CONVERSION CHART, KUTTER'S n TO HAZEN AND WILLIAMS C

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New Methods in the

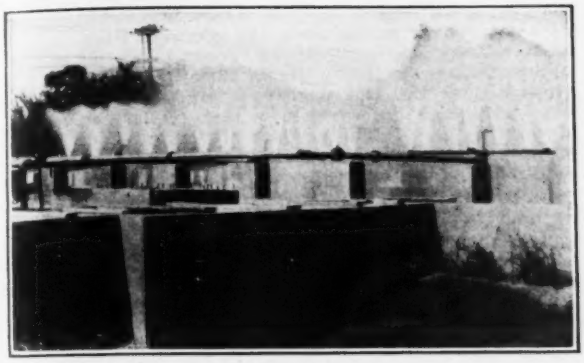
Spray Hot Well Water to Cool for Domestic Use

Temperature of a warm artesian water in Highland Park, a suburb of Dallas, Tex., is reduced by spraying sufficiently to make it acceptable as a drinking water supply. Highland Park has a population of 8,000 and obtains its supply from two artesian wells, 2,865 ft. deep. The wells are drilled into the Trinity sands and yield a water having a temperature of 110 deg. F. For some years there were complaints from the water consumers of this high temperature. It was too warm for bathing or household use without the nuisance of holding for a time. Until the cooling system was installed there was very little reduction in the temperature of the water during the summer months from the time it was drawn from the storage reservoir until it was delivered to the consumers. During the winter complaints were not so numerous.

In 1924, George Fairtrace, city manager, installed a cooling system, consisting of a number of spray nozzles mounted over two concrete storage reservoirs, the water being circulated through the spray nozzles at the rate of about 2,700 g.p.m. The water is delivered from the wells into a storage basin from which it is pumped through the spray system, about 13 ft. head being required. The spray system consists of nine spray groups with seven spray nozzles in each group. The water is sprayed into the air about 7 ft. and falls into the storage reservoir.

During the night when the air temperature is low

Water-Works Field



SPRAY NOZZLES IN ACTION COOLING DRINKING WATER

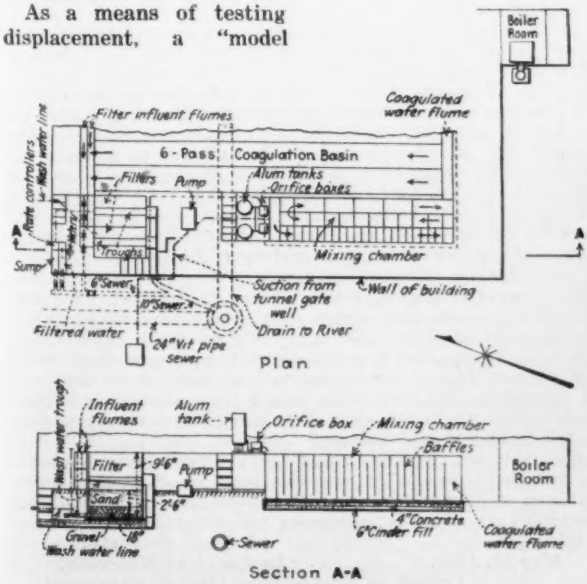
the spray system is most efficient. During this period a reduction in temperature from 110 deg. down to an average of 84 deg. is effected. The average daily temperature of the water leaving the plant is 88 deg. F.

Detroit Experimental Filter Plant

BUILT in the hope of improving present methods of design of coagulation and sedimentation basins, the Detroit experimental filter plant has now been in operation since February and will be continued for a year.

The plant includes two small rapid filter units, used rather as a means of measuring efficiency of coagulation than in an attempt to improve filter design. The main coagulation basin is 50x21 ft. in plan and has a 6-ft. water depth. It is divided longitudinally into six passes which may be operated in series or parallel. Usually it will be divided into two units operated differently and the coagulation results will be compared by applying the water to the two filters. By operating the two basins with different times, lengths-of-travel, and depths, it is hoped to learn to what extent coagulation and sedimentation are functions of volume of basin, surface area and velocity.

As a means of testing displacement, a "model basin" has been built which is a replica, at a scale of 1 to 20, of one of the 15-m.g. basins of the present Detroit filtration plant. The large basins have a single round-the-end baffle and show incomplete displacement, in that some water passes through the basins in less than an hour while the theoretical period is 2 hours.



DETROIT WATER FILTRATION TESTING STATION

Pipe Drilling Standard Holds Two Drills

BY W. W. MONK
Shanghai Waterworks Co., Shanghai, China

THE difficulty of obtaining a good drill standard for drilling holes in pipes of all kinds caused the author to devise the one shown herewith which allows either one or two operations at the same time without shifting machine.

Ratchet drills are supported by the extending arm which will revolve through practically 360 deg.

FIG. 1—STANDARD WITH TWO RATCHET DRILLS

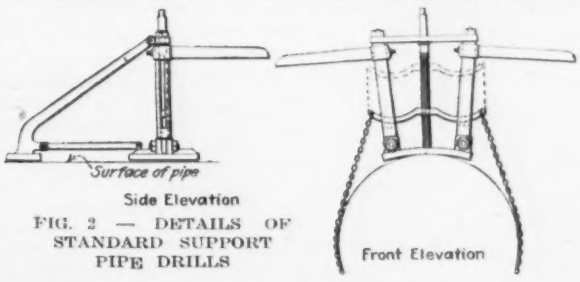


FIG. 2 — DETAILS OF STANDARD SUPPORT PIPE DRILLS

The drawing and accompanying photograph show the apparatus in detail.

Steel Plates Making Up the 75-ft. x 48-ft. diameter standpipe recently erected by the Chicago Bridge & Iron Works under the direction of its foreman, J. Kooyman, for the Milford Water Co., Milford, Mass., were hoisted into place by means of a stiff-leg fastened to the side of the stand-

pipe upon which was secured a block with the necessary tackle running to a drum winch. The winch was operated by a pneumatic reamer as shown on the attached photograph, which has a chuck fitting the square end of the axle, upon which normally the crank handle would be fixed. This ingenious use of equipment at hand is described by Scott Keith, of Metcalf & Eddy, consulting engineers, Boston.

Letters to the Editor

This department aims to be a forum for the discussion of the views of engineers and contractors. The range of interest should be as wide as possible. Contributors are, therefore, asked to make their letters short.

Earthwork Quantity Measurements

Sir—In 1910 the writer was in charge of the construction of the Teller Reservoir and Irrigation Company near Pueblo, Colo. This included an earth dam over 100 ft. high. The conditions were very similar to those mentioned by "Arbitrators" in the letter in *Engineering News-Record*, April 15, 1926, p. 624.

After placing about 300,000 cu.yd. with elevating graders, steam shovels and dump wagons, the contractors decided they would be paid embankment measurement rather than borrow pit as had been done up to that time. The contractors were taking a large percentage of their payments in bonds of the company and were able to dictate, in a large measure, in such matters.

We had sufficient base lines and cross-sections to insure accurate measurements either way. After carefully measuring up we found that the embankment quantities were about 17,000 cu.yd. less than borrow pit measurements, or, about 6 per cent. These figures are from memory and are not guaranteed. L. A. SUMNER.

New Orleans, La.,
April 29, 1926.

San Francisco's Street Railway Is Defended

Sir—I have just read a letter signed by "W" on page 740 of your May 6 issue, entitled "Real Costs of Municipally Owned Railway Cannot be Ascertained."

The letter, from start to finish, is full of incorrect statements, not to mention absolute falsehoods.

The Municipal Railway of San Francisco, since its inception, has kept a true and accurate account of the receipts and expenditures incident to its operation. This has not been grudgingly done and there is annually published a printed financial statement of the railway, which is distributed to many hundreds of different people.

Paragraph 3 of Section 16, Article XII, of the San Francisco Charter, which deals with the subject of public utilities, prescribes how the accounting shall be done and requires that the railway accounts shall be examined at least once a year by an expert accountant. This work has been always done by nationally known certified public accountants and heretofore has not been questioned.

Your correspondent states that it is proposed to reduce the depreciation fund from 18 per cent to 3 per cent of the revenue and to take this difference of 15 per cent to pay increased wages. This statement is entirely wrong for, since the inception of the road, 18 per cent of the gross passenger revenue has been set aside—4 per cent to cover accident and damage claims, and 14 per cent for the purpose of retiring bonds and for depreciation reserve.

Under the new system of accounting 3 per cent of the *cost of the road and equipment* is to be set aside for depreciation. Note that this is *not 3 per cent of the gross receipts*. This 3 per cent will provide about the same sum for depreciation as has been set aside in the past. Of the depreciation reserve, which has already been built up, a portion will be taken as the nest egg of the new depreciation reserve fund, a portion going into the accident and damage reserve fund, the remainder is to be used in additions and betterments. The additions and betterments immediately necessary cannot all be financed out of this remainder and it is proposed to ask the voters to authorize a bond issue of $2,000,000, which, together with the money from the old depreciation reserve, will provide a promised railway extension, new cars, a car shop, and a new car barn. None of this bond money is to go to operating expense.

In the matter of paving, the municipal line is doing exactly the same as the privately owned line in the way of maintaining pavement, only it is doing a 100 per cent better job. The asphalt paving is made by the municipal street repair department, which bills the municipal railway for this service the same as a private contractor would bill a street railway.

Each annual report shows under Account No. 10, as prescribed by the California State Railroad Commission, the actual annual cost of pavement. The capital account of the railway, under account No. 511, carries $861,458.23 as actual expenditures for paving along the municipal lines.

As a franchise condition the privately owned railways agreed to pave the full width of their tracks and for 2 ft. on each side. The municipal lines do not have such a franchise obligation but where new track is laid on a paved street, they do as much paving as the private lines. When a street is paved after the rails are down the municipal line pays only for special expense incident to paving against the rails, which is equal to about one-half the amount expended by the private line.

In 1913 the municipal railway took over the Union St. line from a privately-owned corporation. The scale of wages of the platform men was raised to that of the municipal railway. No superintendent, as reported, was taken over by the municipal railway. The man who was superintendent of the Union Street Line brought suit against the city and tried to force it to take him over. He lost his suit and was never employed by the city. His assistant was taken over and made assistant superintendent in charge of that division. He was paid the same rate with the municipal railway that he had been receiving with the private line. The man who was acting as secretary was taken over by the railway but was not employed as a secretary, but on account of his experience and ability was made claims adjuster for the railway at his former salary.

The above, I trust, indicates how worthless was the criticism submitted by "W." The only truthful statement which he makes is that the rate of fare on the cars remains the same. People in San Francisco, like those in New York are still riding on a 5-cent carfare and receiving first class service—this in spite of the fact that the average fare in the United States at the present time is above 7.6 cents. The municipal railway is breaking even and a little better than breaking even, when compared with privately-owned lines, as, to date, the property has met all of its operating expenses and has constructed additions and betterments costing almost $3,000,000 out of surplus earnings. It has met all interest charges on the capital investment and has paid off bonds against the property to the extent of over $2,000,000. At the present time the property has a reproduction value of approximately $10,000,000.

San Francisco, Calif., M. M. O'SHAUGHNESSY,
May 11, 1926. City Engineer.

Workability of Concrete

Sir—The letter of George A. Smith in the May 13 issue of *Engineering News-Record* refers to the "penetration method" as "the best means thus far developed for measuring workability."

I am wondering if, in the opinion of those familiar with these tests, this statement is entirely justifiable. Irrespective of what the specific definition of workability is, or its relation to so-called plasticity or consistency, the ability of concrete to flow into place wherever that place may be is a prime practical requisite. In practice we aid it in this respect by using more water, by vibration, tamping or rodding, and possibly by the addition of some finely divided material such as Celite or hydrated lime. This particular ability to flow is, in my opinion, measured with good accuracy by the flow table as developed by the Bureau of Standards and used by many investigators at the present time. It is said that the penetration apparatus results "express the relative ease of rodding different concrete mixes." Is it not conceivable that a mix with a rather high percentage of hydrated lime or Celite admixture can be easily rodded, but yet be so sticky that it would not flow well into place without a great deal of extra care in manipulation at the time of placing? The flow table would show that such a concrete would not flow easily. Would not the penetration test be misleading in this respect?

Our tests with admixtures of finely divided materials such as hydrated lime, Celite, and talc seem to show that more water is required to produce the same flowability as these materials are added in increasing percentages.

Ithaca, N. Y. H. H. SCOFIELD,
May 19, 1926. Professor of Materials,
College of Engineering, Cornell University.

News of the Week

CURRENT EVENTS IN THE CIVIL ENGINEERING AND CONTRACTING FIELDS

Elevated Express Highway for New York Approved

Chief Engineer of Board of Estimate Approves Plan for 4-Mile Elevated Structure

The plan of the Borough President of Manhattan for an elevated express highway along the Hudson River water front at New York City has been approved, with some modifications, by the chief engineer of the Board of Estimate and Apportionment of the city. The State Legislature gave its approval of the project at its recent session and authorized the Board of Estimate to take the necessary steps looking towards its construction.

The plan, as modified, calls for a single-deck elevated structure, generally 70 ft. wide, beginning as an extension of Riverside Drive West over the New York Central yards between 72nd and 60th Sts. and extending down 12th, 13th and 11th Aves. and the Marginal Way to the neighborhood of Canal St., where it comes down to grade for connections with the Holland vehicular tunnel. Ramps are provided in the neighborhood of the major cross streets, West 57th St., West 44th St., West 34th St., and West 14th St. The width of the roadway is 60 ft. except in the neighborhood of the ramps, where the structure is given a width of 100 ft. to maintain a road way width for six through lines of traffic. It is estimated that the height of the roadway above the streets will be 19 ft., generally, in order to provide a 14-ft. clearance underneath the structure.

In general, the structure is to be located 20.5 ft. from the curb line or about 40 ft. from the east building line.

Provision for Second Deck

Provisions are to be made in the framing of the structure for an additional deck when traffic conditions warrant. It is estimated that the traffic capacity of the single-deck structure will be 9,000 vehicles per hour, if limited to light passenger vehicles operated at from 20 to 30 miles per hour.

The chief engineer of the board, in his report, states that heretofore all projects of a similar character have been complicated by an incidental attempt to make provision for the freight service of the New York Central R.R. between W. 60th St. and the St. Johns Park terminal south of Canal St., which is now operated on the surface of the street. He states now, however, that he has been advised that the New York Central has devised a plan for removing its tracks from the surface of the streets which will not conflict in any way with the improvement now proposed. Nevertheless, he states, that the carrying out of the plan is dependent upon the prior removal of the tracks of the railroad company in the sections south of West 12th St., or the relocation of the tracks to suit the column spacing of the elevated structure, increasing the height of the structure to give sufficient clearance for the railroad to operate below it.

The estimated cost of the construction of a one-deck structure with provision for the addition of a second deck is placed at $13,500,000, with an addition of $200,000 for easement rights, to which must be added $1,300,000 for acquiring land and the work of constructing the Marginal Way between 38th and 42nd Sts.

Engineering Fifty Years Ago

From *Engineering News*, May, 1876

List of Books for Sale

at the office of Engineering News

Field Books

SHUNK.

A Practical Treatise on Railway Curves, and Location, for the Young Engineers. By W. F. Shunk $2.00

TRAUTWINE.

The Civil Engineer's Pocket Book By J. C. Trautwine. 12mo. 648 pages, tuck. Philadelphia, 1872..... $5.00

Program of the A.S.T.M. Meeting at Atlantic City

The twenty-ninth annual meeting of the American Society for Testing Materials is to be held at Chalfonte-Haddon Hall, Atlantic City, N. J., June 21-25. Monday, June 21, is given over to registration and committee meetings, and the meeting proper opens at 2 o'clock Tuesday. There are 12 sessions, 6 of them in three groups of two simultaneous sessions and 3 simultaneous sessions in one evening. The rest of the period is devoted to single sessions and to recreation and committee meetings and Friday afternoon devoted to the golf and tennis tournaments. Eighty-five papers and committee reports are already reported as scheduled.

Sewer Work in Ohio Held Up

Because of a preliminary injunction granted in the federal court at Columbus by Judge Benson Hough, sewer work amounting to several millions of dollars in Ohio will be held up. The injunction was granted on sewer work projected at Indian Lake but the issue involved affects many other projects, one of which is in Columbus and vicinity involving more than $1,000,000. The complaint was made by property owners who claimed that the assessments on their property were excessive. The projects are principally those either wholly outside or partly outside of municipalities.

E. D. Adams Makes Gift to Engineering Foundation

Endowment Increased by $100,000—Two Important Researches to Receive Financial Support

Edward Dean Adams has made a donation of $100,000 to Engineering Foundation and Engineering Societies Library, according to an announcement made at the annual meeting of the Foundation, held on May 19. This is a material increase of the fund of Engineering Foundation, originally endowed by Ambrose Swasey. Mr. Adams was elected honorary member of Engineering Foundation in appreciation of his service as vice-chairman during ten years.

Support to Research

It was decided to grant financial support to two important investigations. Prof. R. F. McCaffery, University of Wisconsin, will continue a study of blast furnace slags begun some time ago with a view to determining the value of different slags as desulphurizing agents and the possibility of using raw materials of higher sulphur content. The outcome of these studies may extend the range of ores and cokes available for blast furnace work where a low sulphur product is necessary. The sum of $10,000 yearly for three years is to be provided by the Foundation, of which $4,000 will be contributed from its own funds and $6,000 is to be raised from the industries interested. Prof. J. B. Whitehead, of Johns Hopkins University, is to undertake a research in the field of dielectric absorption, a subject recommended by the committee on electrical installation of the National Research Council. In aid of this research a grant of $5,000 yearly for two years was made.

Dr. John A. Matthews, vice-president of the Crucible Steel Co. of America, made an important address at the meeting. He laid stress on the importance of research, and gave expression to serious question concerning the extensive standardization that is now in progress. He suggested that the cost of standard specifications is very large, and that in their effect they are not wholly satisfactory to either producer or user and rarely represent really high-class material.

152 Miles of New Railroad in Alabama and Mississippi

The St. Louis-San Francisco Railway Co. has applied to the Interstate Commerce Commission for authority to construct 152 miles of line from Aberdeen, Miss., to connect with the Muscle Shoals, Birmingham and Pensacola Railroad at Kimbrough, Ala. The new line is to afford the applicant an outlet to the Gulf of Mexico by way of the Muscle Shoals, Birmingham and Pensacola Railroad, which it purchased recently.

Steel Working Stress of 18,000 Adopted by Committee

Agreement was reached recently by the Conference Committee of the American Society of Civil Engineers and the American Institute of Steel Construction, appointed to consider harmonizing the recommendations of the two organizations for structural steel working stresses. The committee voted to recommend that the standard specification of the American Institute of Steel Construction, based on a working stress of 18,000 lb. per square inch, be adopted for the present, as containing conservative and safe working stresses. It also expressed the belief that in the not distant future a further increase in basic unit stresses, as recommended in the majority report of the American Society of Civil Engineers committee (20,000 lb. base) may be recommended.

The committee supported its recommendation by referring to the diversity of steel designing practices of different building codes in current use, the adoption by a large number of cities of the 18,000 lb. specification formulated in 1923 by a board of architects and engineers acting for the American Institute of Steel Construction, the fact that the 16,000 lb. basic working stress has been in use for about 25 years, while the methods of the art have greatly improved, and the more reliable character of the steel produced today as against that produced formerly, warranting its more efficient use.

The committee consisted of the following representatives: For the American Society of Civil Engineers, H. G. Balcom, C. E. Chase, F. O. Dufour, J. H. Edwards, L. J. Towne; and for the American Institute of Steel Construction, Geo. F. Swain, Milo S. Ketchum, Paul Willis, Clyde McCornack, and L. H. Miller.

Reclamation Commissioner Mead Given $10,000 Salary

Congress has approved a special bill providing that Dr. Elwood Mead, commissioner of reclamation, is to receive a salary of $10,000.

Dr. Mead was called to Washington to take charge of reclamation when an emergency theatened the service. He was receiving a salary of $11,000 as a member of the faculty of the University of California and came to Washington only because it was urged upon him as a patriotic duty. Secretary Work did all in his power to convince Congress that it is unbecoming, under the circumstances, to cut the pay of a man who was making other sacrifices because public service was urged upon him. It was pointed out to the respective committees that, among others, members of the War Finance Corporation; of the Shipping Board; of the Interstate Commerce Commission and of the Federal Reserve Board receive $12,000. The chief examiner of the Federal Reserve Board gets $13,000; the general manager of the Alaska Railroad $14,400; the general counsel of the Railroad Administration $15,000. In a few instances even higher salaries are paid competent specialists.

Progress on East Bay Water Supply Project

Lower Section of Conduit Well Along—Welding of Field Joints Gives Way to Riveting

Construction is now well under way on some of the tunnels and pipe line of the Mokelumne project which is to bring a new water supply to Oakland, Calif., and other municipalities in the East Bay Municipal Utility District. The lower 42 miles of the conduit from the San Joaquin River crossing to the district are being built first, thus tapping an emergency source whence water could be taken and treated before Mokelumne water, 48 miles farther away, is available. Contract awards on this project were announced in *Engineering News-Record*, Oct. 8, 1925, p. 608, and in the issue of April 29, p. 708, announcement was made of the favorable decision in the District's application for water rights.

Although contracts for work east of the San Joaquin River crossing have been awarded they contain the proviso that they become valid and construction shall begin only when the contractor is notified by the District. Time limits on the contract for Lancha Plana dam and the intake tunnel expire Oct. 30 and on the pipe line, June 29.

Meantime work has been advanced rapidly on contracts west of the San Joaquin crossing. For the first 34 miles west of the river the conduit will be 65-in. steel pipe (except a short stretch of 63-in. pipe). Then, westerly from the east portal of Walnut Creek tunnel, a larger section will be used in tunnels and conduit to provide for the ultimate 200 m.g.d. capacity. Walnut Creek tunnel is ½ mile long, then comes a 3.5-mile concrete conduit, then Lafayette tunnel, 3 miles long, and finally Claremont tunnel, 3¼ miles long. The initial capacity of the steel pipe line, under gravity flow, will be 37.5 m.g.d., this to be raised to 60 m.g.d. when the Walnut Creek pumps are installed.

Recent Progress

The following has been taken from a progress report dated May 14, signed by A. P. Davis, chief engineer and general manager of the East Bay Municipal Utility District: On the pipe line west of the San Joaquin River crossing 13,340 ft. of trench has been excavated, 10,170 ft. of pipe has been laid and welded and 20,590 ft. of pipe has been delivered to the field; a total of 929 pipe sections, 30 ft. long, have been welded in the shop. The contractor has been ordered to discontinue the welding of circumferential joints in the field, these field joints to be made hereafter as riveted butt strap joints. A 3,600-ft. length of pipe in the trench has satisfactorily passed a hydrostatic test of 197 lb. per sq.in.

Walnut Creek tunnel has been driven and trimmed to shape and about half the concrete lining in the arch has been placed. In Lafayette tunnel, 42.1 per cent of the length has been driven and 8 per cent of the concrete lining has been placed. Bids have not yet been received on Claremont tunnel but plans and specifications have been prepared, of which 39 sets have been called for.

Washington Planning Commission Appointed by President

The President, on May 19, named the following men as members of the National Capital Park and Planning Commission: Frederick L. Olmsted, landscape architect, Brookline, Mass., Frederick A. Delano, chairman of the committee on the Regional Plan of New York and Environs, J. C. Nichols, city plan expert of Kansas City, and Milton R. Medary, Jr., president of the American Institute of Architects. These men are to serve for six, five, four and three years respectively. Other members of the commission are the Chief of Engineers, Major General Harry Taylor; the Engineer Commissioner, District of Columbia, Lieut. Col. J. Franklin Bell; the Director, National Park Service, Stephen T. Mather; Chief of the Forest Service, W. B. Greeley, the chairman of the Senate and House district committees, Arthur Capper and F. N. Zihlman, and the Director of Public Buildings and Grounds, Major U. S. Grant, 3d.

The National Capital Park and Planning Commission was authorized recently by Congress to develop a comprehensive plan for the National Capital and its environs and to develop the park and parkways.

Engineers Give Dinner in Honor of Ousted St. Louis Official

Between 200 and 300 engineers and prominent citizens of St. Louis joined in honoring Edward E. Wall in a testimonial dinner given under the auspices of the Associated Engineering Societies of St. Louis at the Engineers Club of St. Louis on May 17. The dinner was given to express the admiration and respect which the engineers and citizens in general in St. Louis have for Mr. Wall, and as protest against his removal from the position of director of public utilities after 34 years of faithful service to the city. Among the speakers at the dinner were two former mayors of St. Louis under whom Mr. Wall had worked and three members of the former Board of Public Improvements. Edward Flad, one of the latter, said that Mr. Wall "could have remained in office if he would have consented to violate the city charter, but his conscience and his concept of duty forbid, and he has returned to the ranks of private citizens." This dinner, said Mr. Flad, should be an encouragement to young engineers in public service.

Milwaukee's Civic Alliance

The original Milwaukee Civic Alliance, established in 1922, has been reorganized on a wider basis to represent the various local clubs and civic organizations at Milwaukee, Wis., in the study and discussion of matters of community interest. Each organization will be represented in the Alliance by its president and secretary and by not more than two additional members. The Engineers Society of Milwaukee is represented in the Alliance by F. C. Trubshaw, president; Robert Cramer, secretary, and F. W. Ells.

Industrial Conference Board Holds Its Tenth Anniversary

The National Industrial Conference Board celebrated the tenth anniversary of its founding on May 20 in a meeting held at New York City. Frederick P. Fish, chairman of the board since its organization, has been succeeded by Loyall A. Osborne, president of the Westinghouse Electric International Co., Mr. Fish having declined re-election. Magnus W. Alexander continues as president.

Reporting upon the ten years of activity of the board, Mr. Alexander stated that it spends approximately $300,000 a year in getting together facts regarding industry and related business and social conditions. The results of the board's work have been published through 115 research and 35 special reports and many monographs, bulletins and charts. In addition, much special service has been rendered to subscribers of the board, governmental organizations, and others. The investigations of the board have covered such subjects as wages and hours of work, cost of living, industrial pensions, cost of government, and the economic significance and legal status of trade associations.

Commerce Commission Acts on Oregon R.R. Projects

Acting upon the complaint of the Public Service Commission of the State of Oregon which sought an order for the construction of several lines of railway within the state, the Interstate Commerce Commission has issued an order authorizing the construction of certain railway lines in Oregon, applications for which authorization have been pending with the commission for some time, but not ordering other construction which the Oregon commission desired. Details of the various projects have been given in *Engineering News-Record* in the issues of Oct. 16, 1924, p. 635, Jan. 15, 1925, p. 104, April 16, 1925, p. 666, and June 18, 1925, p. 1036.

In general, the Interstate Commerce Commission has approved the construction of certain lines in the interior portion of Oregon for which individual railroads have made application to it for authority to build, but declined to order the construction of a new east and west line across the central portion of the state as desired by the state Public Service Commission. It has acted upon the basis that it should authorize as little construction as is possible in order not to make an undue drain upon the finances of any one railroad company.

In detail, the commission has authorized, conditionally, the construction by the Oregon Trunk Ry. (subsidiary of the Great Northern and Northern Pacific Ry.) of a line from Bend, in a southwestly direction, a distance of 66 miles, to a point near Paunina, a station on the newly-constructed Natron cut-off line of the Central Pacific (Southern Pacific), thence southeasterly a distance of 70 miles to Sprague River, thence south and west, 42 miles, to Klamath Falls, a total distance of 178 miles. The Oregon, California & Eastern Ry. has been authorized, conditionally, to construct a 63-mile branch to Silver Lake, and from a point on the Silver Lake branch approximately 20 miles north to Sprague River and thence northwesterly along the Williamson River approximately 15 miles, and a branch from Sprague River southeasterly approximately 65 miles to Lakeview. The Southern Pacific has been authorized conditionally, to acquire control of the Oregon, California & Eastern Ry. The Central Pacific Railway Co. (Southern Pacific) has been authorized to construct a new line from near Klamath Falls southeasterly to Cornell, in Modoc County, Calif., 36 miles, thence 62 miles southeasterly to Alturas, Calif.

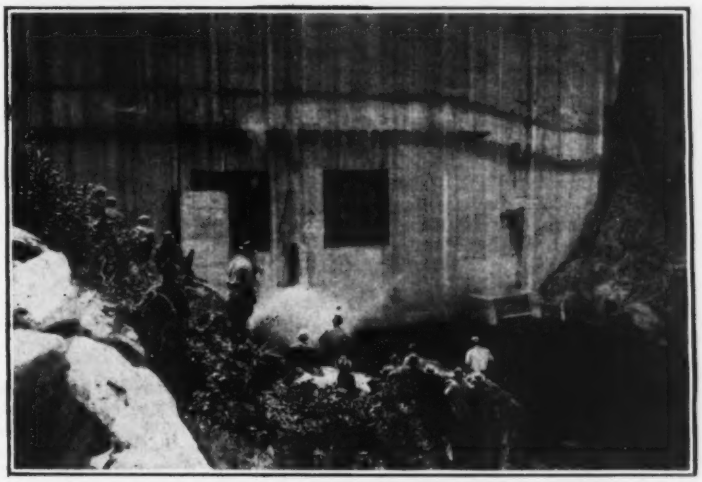
Authority for all but the latter construction is conditioned upon the granting or obtaining of certain traffic or operating rights. These conditions will be given in more detail in a subsequent issue.

Gates Closed and Storage Begun at Exchequer Dam

On April 20 oxyacetylene torches cut the steel cables supporting the concrete gates over the temporary openings through the Exchequer Dam in California, thereby letting the gates drop and beginning storage in the reservoir. The flow through the openings when the gates were dropped was 3,000 sec.-ft. Details of the scheme by which closure was to be effected with these gates was published in *Engineering News-Record*, March 11, p. 418.

When the cables were cut, the gates slid down successfully into position and seated themselves properly. After the closure the leakage around the gates was found to total 3 sec.-ft. and this was reduced by the use of wedges and oakum to ½ cu.ft. which was collected in pipes controlled with valves and led into the inspection gallery. A concrete plug was then placed a short distance back of the upstream face after which the remainder of the opening could be filled at leisure.

On May 4 the total head of water behind the dam was 190 ft., with a total storage of 64,000 acre-ft. By this time the machinery had all been assembled in the power house and the plant was scheduled to be ready for regular service by June 1. The finishing touches on the construction work are to be done and all the construction equipment removed by about the middle of July.



DROPPING GATES TO EFFECT CLOSURE OF EXCHEQUER DAM
The two gates went down ten seconds apart, this view was taken before second gate started. Note forms for closure of railroad opening in right background. Last train passed through this opening two days before closure.

New Bids Submitted on Piers for Mid-Hudson Bridge

Four new proposals for the construction of the river piers of the Mid-Hudson bridge being built across the Hudson River at Poughkeepsie, N. Y., were received by the State Superintendent of Public Works on May 19. The bids were as follows:

Blakeslee-Rollins Corp. of Boston	$1,889,925
The Arundel Corp. and Vang Construction Co., Baltimore and Cumberland, Md.	1,895,872
Triest Contracting Corp., New York City	1,979,031
Missouri Valley Bridge & Iron Co., Leavenworth, Kan.	2,025,905

The engineers' estimate for this work was $2,145,535.

This is the second bidding on the piers for this bridge. The first bids were received on March 30. They were as follows:

Phillipsburg Construction Co., Yonkers, N. Y.	$1,841,545
Triest Contracting Corporation, New York, N. Y.	1,916,440
Missouri Valley Bridge & Iron Co., Leavenworth, Kans.	2,102,517

The contract was awarded to the Phillipsburg Construction Co., as low bidder, but the company failed to furnish the required surety bond and the work had to be re-advertised.

More Engineers and Architects Needed for Government Work

Due to the small number of applications received for positions as architects, mechanical and structural engineers on the government's proposed $165,000,000 public building program, the Civil Service Commission has extended until June 30 the date for the close of receipt of applications, and has raised the age limit of 45 to 50 years. Full information and application blanks may be obtained from the U. S. Civil Service Commission.

WASHINGTON NOTES

SO AS to permit the Coast and Geodetic Survey to complete its triangulation of the Cascade mountains, in Washington, during this field season the President has asked Congress to make available immediately the funds for the purpose, which otherwise could not be used until after July 1.

THE sub-committee of the House Committee on the Judiciary, which has been considering the Campbell bill, which provides for the regulation of the amount of day labor used in the construction of public works, has reached the conclusion that certain fundamental changes in the bill are necessary and has asked that the measure be considered by the full committee. It was stated by the Judiciary Committee that it is going to be very difficult for the full committee to give consideration to this measure at this session of Congress.

AFTER submitting to the Senate an extended argument, supported by numerous statistical tables in behalf of the federal aid highway bill, Senator Oddie, of Nevada, in charge of the measure, gave assurances that the bill would be brought to a final vote at this session of Congress. It is understood that the opposition will not attempt to debate the measure at length.

The bill, which was passed by the House April 16, carries authorizations for $75,000,000 for federal-aid roads during the fiscal years 1928 and 1929. In addition, $7,500,000 is carried for forest roads and trails.

ACTIVE work has been started on American Engineering Council's study on the relationship of safety and production. The study is to cover ten basic industries as follows: Iron and steel; steam railroads; cement; mining; wood-working; metal trades; paper and pulp; textiles; electric utilities, and building construction. The four industries first mentioned will be studied from records already available. The remainder will be covered by field engineers. An engineer will be stationed in each of the following industrial centers: Boston, New Haven, New York, Philadelphia, Baltimore, Syracuse, Buffalo, Pittsburgh, Cleveland, Cincinnati, Detroit, Grand Rapids, Chicago, Milwaukee, St. Louis and Atlanta. The Wilmington study will be directed from Philadelphia, that of Louisville and other Kentucky cities from Cincinnati, while Atlanta simply will be headquarters for those engaged in the study of the Southern textile industry. In each of the places mentioned the work will be conducted under the direct supervision of a local advisory committee drawn from the sections of the National engineering societies, other engineering bodies and the local safety councils. The field work is to be completed by September 1.

Data will be gathered from some 2,000 plants. Records showing the accident frequency rate and its bearing on the rate of production will be studied over as long a period as new records are available. In addition a specific study will be made to determine what occurs incidental to the loss of man hours, machine hours and curtailed production.

ALL probability of advancing further the Boulder Dam legislation at this session of Congress vanished when the House Committee on Irrigation and Reclamation, May 21, voted to table the revised Swing-Johnson bill. The so-called power amendments prepared by Representative Leatherwood, of Utah, were withheld until the time should be more propitious for their formal presentation.

Senator Johnson, of California, is planning to make a speech on the subject and an effort may be made to bring the bill to a vote in the Senate. It is not believed, however, that it can be passed, despite the fact it is on the calendar with a favorable report.

It is expected that some new plan will be brought forward at the next session. This may take the form of a proposal for the construction of a project by public corporation which would construct and operate the dam and power house, but would sell the output to the highest bidder.

Some are of the opinion that Arizona may modify its position after the gubernatorial elections this fall.

Franklin Institute Medal Awarded To Samuel Rea

The American award of the medal of the Frankiln Institute of Philadelphia, for 1926, has been made to Samuel Rea, former President of the Pennsylvania R.R. Co., an engineer who began his career as a chainman on the Pennsylvania Railroad when 16 years old, and worked his way up to the presidency. The award which accompanied Mr. Rea's medal states:

"In recognition of his outstanding work in the conception and construction of railroads, their terminals, tunnels and bridges, and of his eminently successful application of the principles of science, economics and human relations to railway engineering and administration, in which he displayed vision, imagination and courage of high order."

Large Bond Issue at Pittsburgh Approved by Voters

The voters at Pittsburgh, Pa., on May 19, approved by a large majority the 10 propositions for special bond issues submitted to them. Large items in the bond issue program are: For improvement in the water-works system, $3,900,000; for replacement of bridges, $1,450,000; sewer construction, $2,000,000; improvements to major thoroughfares, $6,127,000; construction of buildings and rehabilitation of the City Home and hospital at Mayview, $2,500,000; for completion of the 1919 highway bond project, $1,870,000, and for completion of the 1919 bridge projects, $455,000.

RANDOM LINES

Pedantry

We defer to no one in our respect and reverence for the Latin language—when it is kept where it belongs. But there is no use letting it mess up the English language, which may not have got started quite so early in the game but which has just as long a history of reputable use. Why, for instance, do engineers torture the plural of "stadium," that omnipresent modern equivalent of the gladiatorial arena, into "stadia," when every engineer who has ever twiddled a thumbscrew knows that "stadia" has another, and widely different, meaning. What's wrong with "stadiums?"

* * *

Dressing the Part

We have just been looking over the *American Architect's* excellent collection of snapshots of the prominent architects at the recent Washington convention of the American Institute of Architects. Four out of five carry walking sticks. There's an idea here for the engineer. Maybe if a similar habit could be cultivated by those engineers who occasionally manage to appear in such raiment as befits a stick, there could be developed that nice appreciation of one's profession and one's self that so distinguishes the architect. A stick and an inferiority complex simply cannot co-exist.

* * *

More Additions to the List of Fancy Engineers

(174) *Pediatric Engineer* — From the *New Yorker*—

"DR. M—— Pediatric Engineer. Certificate of Merit for relieving a severe case of Foot Trouble with Dr. S——'s Foot Comfort Appliances."—*Sign in Third Avenue Window.* One more sign of the advance of science in this age of specialization.

(175) *Ice Engineer*—There seems to be some difference of opinion as to definition; e.g., the two following examples.

(a) The lady who tells how she waters her plants with the water from the refrigerator has been misinformed as to the ammonia in the ice water.

"My husband is an *ice engineer*, so he should know."—MRS. E. M.

(b) "This is one of the most fascinating subjects imaginable," said Prof. H. T. Barnes. "I came here to help you men because I realized that there are few *ice engineers* in the country; ice engineering technique is so different from ordinary engineering, and there are so few specialists in it."

(176) *Diplomatic Engineer* — From a Rochester, N. Y., paper.

Newport News Buys Water-Works for $3,300,000

By a 5 to 1 vote on May 18 the electors of Newport News, Va., approved a $3,300,000 bond issue for the purchase of the water-works plant owned by the Old Dominion Land Company. The property comprises impounding reservoirs with 9,000 acres of timbered drainage area, all mechanical equipment and the pipe system. The bonds have not been sold but it is expected that the city will take over the works about July 1.

Two Branch Lines to Be Built By Union Pacific R.R.

The Union Pacific Railroad Co. has been authorized by the Interstate Commerce Commission to construct a branch line in Scotts Bluff County, Neb., from a point near Lyman, in a southerly direction about 6 miles, with a branch from said proposed line extending southeasterly, approximately 2 miles, and a branch from a point near Gering, in a southerly and westerly direction a distance of approximately 10 miles. The two branch lines are for the development of agricultural country. Construction is to be started before July 1, 1926, and completed before the end of 1927.

Special Train from West to Water-Works Convention

A "water-works special" from Chicago to the convention of the American Water Works Association, held this year at Buffalo, is assured for the first time in several years, due to the activity of the Chicago membership in going after the 1927 convention. An enthusiastic meeting May 24 of more than 30 members perfected plans and outlined preliminary features in caring for the convention next year. The Chicago special leaves over the Michigan Central, Sunday, June 6 at 7:55 p.m. and arrives at Buffalo Monday at 8:30 a.m. There will also be a "special" from New York City, leaving Sunday morning, June 6; for transportation on the latter apply to W. H. Van Winkle, 50 Church St., New York City.

Work Starts Again on Railway to Hudson Bay

After having been stopped since the early days of the war, construction work on the Hudson Bay Ry. has been started by the Canadian National Rys. The Dominion Government has included in its estimate for railway work for this year an item of $3,000,000 for work on the Hudson Bay Ry., and it is expected that this will be sufficient to lay track through to Port Nelson this year. There is a large amount of work to be done at Port Nelson on terminal facilities and there are two large bridges to be built before the tracks can be connected through to that point. The estimated cost of completing the work is stated to be $6,000,000.

Calendar

Annual Meetings

CONFERENCE OF STATE SANITARY ENGINEERS, Washington, D. C.; Annual Meeting, Buffalo, N. Y., June 5 and 7, 1926.

AMERICAN WATER WORKS ASSOCIATION, New York City; Annual Meeting, Buffalo, N. Y., June 7-11, 1926.

AMERICAN ASSOCIATION OF ENGINEERS, Chicago, Ill.; Annual Convention, Philadelphia, Pa., June 14-17, New York City, June 18-19, 1926.

SOCIETY FOR PROMOTION OF ENGINEERING EDUCATION, University of Pittsburgh; Annual Meeting, State University of Iowa, Iowa City, June 16-18, 1926.

AMERICAN SOCIETY FOR TESTING MATERIALS, Philadelphia, Pa.; Annual Meeting, Atlantic City, N. J.; June 21-25, 1926.

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York, N. Y.; Summer Meeting, Seattle, Wash., July 14-16; Annual Convention, Philadelphia, Pa., October 4-9, 1926.

NEW ENGLAND WATER WORKS ASSOCIATION, Boston, Mass.; Annual Meeting, Providence, R. I., Sept. 14-17, 1926.

INTERNATIONAL CITY MANAGERS' ASSOCIATION, Lawrence, Kansas; Annual Convention, Colorado Springs, Colo., Sept. 21-23, 1926.

The New York Section American Society of Civil Engineers, at its annual meeting, May 19, elected the following officers for the ensuing year: president, Col. J. R. Slattery; vice-president, H. Malcolm Pirnie, directors, Harold M. Lewis and Burt B. Hodgman; secretary, Harry D. Winsor. Reports of the committees on their work during the past year were also made. The treasurer's report showed the section in exceptionally fine financial condition. Votes of thanks were extended to the program committee for its work and also to George J. Ray, the retiring president.

In addition to the business transacted at the meeting, two papers were presented: "Planning the State of New York" by Sullivan W. Jones, New York State Architect, and "The Westchester County Park System" by Jay Downer, chief engineer, Westchester County Park Commission.

The International Mid-Continent Engineering Convention is to be held at Duluth, Minn., Aug. 12, 13 and 14.

Personal Notes

GEORGE C. ANDREWS, Buffalo, N. Y., former water commissioner of Buffalo and at present in charge of the construction and operation of the Buffalo filtration plant, has been awarded by Lafayette College the degree of doctor of engineering in recognition of his work on the filtration problem and of his engineering accomplishment in connection with the building of the canal locks at Lockport, Ill., where he was formerly engaged as engineer. Mr. Andrews graduated from Lafayette College in 1906.

P. S. MONK has been appointed division engineer in charge of maintenance of the recently created Bureau of Bridges and Structures, Pittsburgh, Pa. The appointment of the chief engineer and other division engineers of the bureau was announced in our issue of May 13, p. 788.

FRANK T. SHEETS, chief state highway engineer of Illinois, is now associated in an advisory and consulting capacity with the engineering firm of Barker, Flavin, Sheets and Wallace, Inc., engineers, with offices in the Burnham Building, Chicago, Ill.

MAJ. J. C. H. LEE, Corps of Engineers, has been relieved of duty in the office of the Chief of Engineers at Washington and has been ordered to Vicksburg, Miss., for river and harbor work and other duties.

Obituary

ANDREW O. CUNNINGHAM, St. Louis, Mo., formerly for sixteen years chief engineer of the Wabash R.R., and since 1924 consulting engineer in river improvement work, died May 11 at his home in University City, Mo., aged 62 years. During his consulting practice he was retained as consulting engineer to the Terminal Railroad Association of St. Louis. Last year he was elected mayor of University City, Mo. Mr. Cunningham was born in Ragoon, India; when he was fifteen years old his parents returned to England, and he soon came to the United States. He worked in the harvest fields in the Northwest, and later graduated from the University of Minnesota in civil engineering. He entered the service of the Wabash R.R., and after several promotions became its chief engineer in 1908.

RICHARD W. SHERMAN, Utica, N. Y., civil engineer and twice mayor of Utica, died May 23 in his 87th year. Mr. Sherman was one of the pioneer railroad and public works engineers in New York State. In 1866 he was engaged in the construction of the Binghamton, Chenango & Susquehanna Valley R.R., now part of the Delaware, Lackawanna & Western system, and later he helped build roads now part of the Ontario & Western system. In public works construction, he formed in 1875 a civil engineering partnership with Dr. Emmet Flagler of Watervliet, N. Y., and they erected water-works at Watervliet, Gloversville and other places including Greenwich, Conn. The firm of Sherman & McDonough was organized in 1881 and constructed water-works in many cities and also did some sewer and railroad construction. In 1888 Mr. Sherman organized the Troy Public Works Co. and was its director for many years. He was twice elected mayor of Utica and twice declined the nomination.

From the Manufacturer's Point of View

A Point of Contact Between Maker and User of Construction Equipment and Materials

Solution-Feed Chlorinator Patent Upheld

The Paradon solution-feed apparatus for applying chlorine to water and sewage for sterilization purposes was held on May 17 by the United Circuit Court of Appeals, Second District, to be a contributory infringement of Claims 4, 5, 6, 8 and 10 of the Ornstein U. S. Patent No. 1,142,361, of which the Electro Bleaching Gas Co. is the owner and Wallace & Tiernan Co., Inc., sole licensee. The decision upholds that of the District Court for the Eastern District of New York, from which the appeal was taken. (*Engineering News-Record*, Nov. 19, 1925, p. 867.)

The higher court, Justice Hough rendering the decision for Justices Rogers, Hough and Mack, says that all five of the claims cited are for a process, the nature of which is sufficiently indicated by Claim 4: "In the sterilization of flowing water, the process which comprises establishing a separate minor flow of water, causing such minor flow to spread out in one portion of its path to present an extended surface, contacting chlorine gas with such flow in such portion of its path, thereafter uniting such minor flow of water with the main body of flowing water to be sterilized, and controlling the quantity of chlorine supplied to the main body of flowing water by controlling the rate of supply of chlorine gas to the minor flow of water."

The court states that although the patent claims at issue are on process only and the defendant merely makes and sells a mechanical device, it is an admitted fact that so far as process is concerned the Paradon device "is substantially identical" with the Wallace & Tiernan device, even though there is "a difference (asserted to be very material) between the device made and sold by the defendant and the means of utilization disclosed by Ornstein in his application."

The validity of the Ornstein patent as affirmed in the court below and also in the U. S. District Court for the Western District of Missouri, is accepted by the Court of Appeals.

After considering the Ornstein claims, first establishing a "separate minor flow of water," then causing the flow to "spread out" and to "present an extended surface" to a counter flow of chlorine gas, and after noting that both the Paradon and the Wallace & Tiernan device apply the chlorine by "an injector just as the water is flowing out as a result of a passage through a throat or strait," the higher court declares that Ornstein's method of "filming out" and that of the defendant's device are to be regarded as equivalents.

The Paradon Engineering Co., in announcing that the "litigation will be carried on," claims also that the decision affects only one type of its chlorinators.

Concrete Road Yardage

For April the square yardages included in concrete pavement contract awards, according to the Portland Cement Association were: 8,758,195 for roads; 4,324,729 for streets; and 479,763 for alleys; or a total for the month of 13,562,687 sq.yd.

The accompanying table summarizes the statistics for the current year:

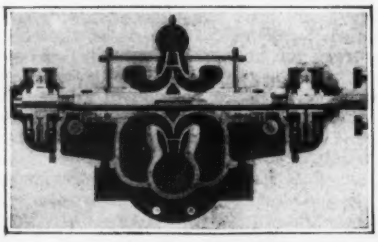
SQUARE YARDS OF CONCRETE PAVEMENT AWARDED DURING 1926

Month	Roads	Streets	Alleys	Total All Classes
Jan.....	2,161,415	1,410,201	57,218	3,628,834
Feb.....	2,726,611	2,010,941	274,836	5,012,388
March..	4,662,885	3,050,630	224,879	7,938,394
April....	8,758,195	4,324,729	479,763	13,562,687
Total..	18,309,106	10,796,501	1,036,696	30,142,303

Equipment and Materials

High Speed Centrifugal Pumps

During the past year the Allis-Chalmers Mfg. Company, Milwaukee, Wis., has put on the market a line of 3,500 r.p.m. single-stage centrifugal pumps. These pumps are of the double



suction type with split casings and are bronze fitted. They are built in sizes as small as 2 inch suction by 1½ inch discharge. It is claimed that the 2½x2 inch pump will deliver 250 gallons against 190 ft. head with a guaranteed efficiency of 74 per cent.

Steel Banded Cast-Iron Pipe Introduced Into United States

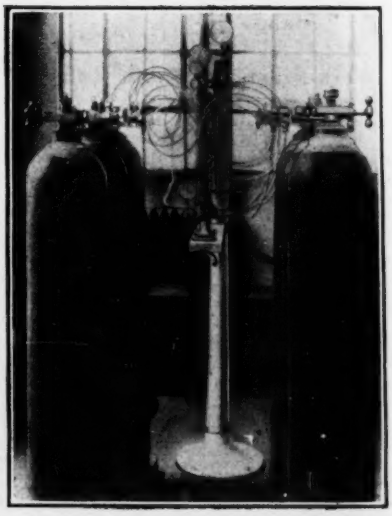
Pont-a-Mousson Foundries, Nancy, France, has been manufacturing steel banded cast-iron pipe for over 40 years. This pipe has been accepted for high pressure lines in Europe instead of using Class E and F as is the practice in this country. The wall thickness of the pipe is very light, corresponding approximately to Class A or B, but it is reinforced by heavy steel hoops shrunk on over lead surfaces at intervals along the pipe. Bursting tests are said to have shown that fractures are confined between the bands, but it is also claimed that on no installation has a break ever occurred. Over 30 years ago Paris laid about 35 miles of 30- to 60-in. standard pipe lines, an illustration of one of which is shown herewith.

This pipe is being introduced into the United States by B. Nicoll & Co., Inc., New York City. It is manufactured in the ordinary way in vertical

molds, except that the grooves for the steel bands are placed in the pipe wall. The pipe is tested to slightly over 200 lb. before the bands are applied. These bands are made of steel and are applied hot, liquid lead being poured into the small space between the band and the pipe. Upon cooling, the steel band tightens onto the pipe compressing the lead in the groove. The pipe comes in 4 meter lengths.

Chlorinator Works Automatically With Water Supply

An important feature of the new type chlorinator recently installed by the Paradon Engineering Co., Long Island City, N. Y., for the water department at Buffalo, consists of an automatic hydraulically operated chlorine shut-off which turns off the supply of chlorine when no water is being supplied to the injector of the apparatus. This chlorinating unit, known as the



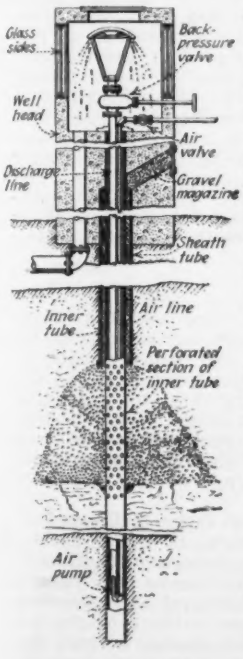
Ashokan type, is built primarily for handling large capacities of chlorine. It was originally developed for the New York City water department and the first unit (*Engineering News-Record*, Aug. 27, 1925, p. 365), has been in operation for about a year and a half at the Ashokan head works on the Catskill system of New York City.

Another feature of the apparatus is a new type vacuum relief which prevents flooding when the unit is shut down. This device allows all the chlorine remaining in the apparatus to be absorbed by moisture without forming a vacuum in the machine and allowing this moisture to be drawn up into the control mechanism. The unit has a capacity of 300 lb. of chlorine per 24 hr.

New Air-Lift Well Design Keeps Screens Open

Sand and gravel strata often occurring at comparatively shallow depth are frequently passed over in favor of deeper strata of other material for the location of wells. This is because sand almost invariably clogs the screens, reducing or stopping the flow of water.

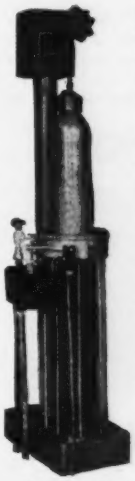
Air-lift pumping systems have been manufactured by the Sullivan Machinery Co., Chicago, Ill., for some time which contain no moving parts that can be cut by the action of sand and gravel. By reversing the normal flow of air and water in one of these wells, the fine sand can be stirred up and floated, after which it may be pumped through the screen. At the same time the coarser gravel is drawn in around the screen and through this the water has an uninterrupted flow into the pumping system. For locations where coarse gravel does not exist, the Sullivan Machinery Co. has recently developed a modification of the air-lift system which it calls the "air-made" well. A large passage is provided around the well casing connected at the top with a magazine, down which coarse screened gravel is poured. As the fine sand is pumped out at the bottom, this coarse gravel keeps working down into the space left free for it until a gravel bed is provided around the strainer. By use of a back pressure valve the gravel deposit may be cleaned of any fine sand that finds its way into it.



The company claims that its common experience shows that after the installation of these air-made wells the volume of water is increased from 50 to 250 per cent up to a certain maximum, and then is maintained at the maximum over long periods.

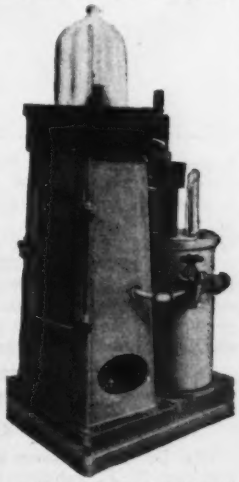
Automatic Chlorinating Apparatus

Two new types of chlorine feed apparatus are being featured by Wallace & Tiernan Co., Newark, N. J. One of these is equipment for the automatic control of the vacuum type chlorinator which proportions the flow of chlorine to the flow of water, and the other a device which supplies a prepared chlorine solution and is intended for small gravity supplies where rates of waterflow are so small that liquid chlorine is not applicable. For the automatic control of the vacuum type chlorinator the differential heads obtained by the flow of water through a venturi tube, an orifice plate, a pivot rod, or the head from the flow over a weir, is transmitted to a differential reducing device which varies the vacuum head on the chlorine feeder precisely in accordance with the flow of water to which the chlorine is being applied. A test of one of these units after several weeks' operation indicated that the average variation of actual chlorine flow from the theoretically correct chlorine flow was .38 of 1 per cent.



CHLORO-CLOCK

The chloro-clock for metering and feeding small quantities of sterilizing solution operates on the displacement principle, the control being obtained from a clockwork mechanism actuating an arm from which a displacing cylinder is suspended. The apparatus is known as a chloro-clock. The rate of feed of chlorine is so arranged that the contents of the cylinder container can be discharged at varying rates as required, from 20 hours to 8 days. A water supply under pressure feeds the small constant level box into which the solution drops. The same water supply also operates an injector which draws from the level box and applies the diluted sterilizing solution to the water supply.



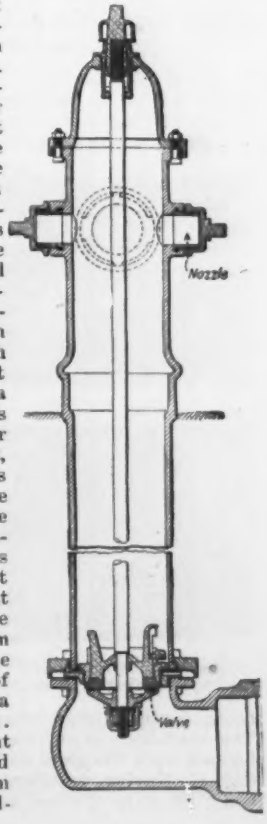
AUTOMATIC VACUUM SOLUTION CHLORINATOR

Latest Type Operating Table

For municipal filtration plants, the International Filter Co., Chicago, has developed an operating table embodying several improved details. The four-way hydraulic cocks have been improved and the valve-opening indicator mechanism much simplified. A combination gage is also a part of the table which, in addition to its normal function of recording, shows loss of head and rate of flow.

Compression Type Fire Hydrant Automatically Drained

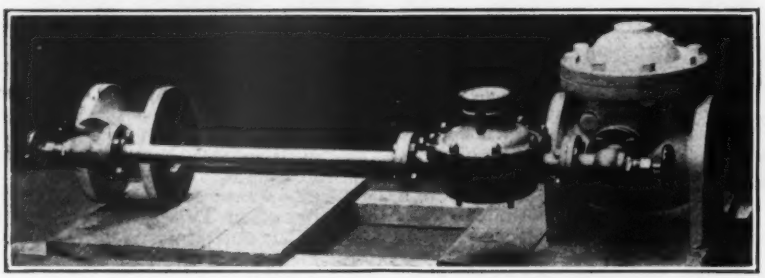
As a result of a study of the operating troubles which are experienced by men actually in charge of fire hydrant maintenance, the Michigan Valve & Foundry Co., Detroit, Mich., has added improvements to its compression type fire hydrant. In the first place the hydrant has an automatic drip. Air is permitted to enter the hydrant through the threads at the top of the stem when the hydrant valve is closed and the drop open, and this feature allows the standpipe to drain readily. With the hydrant valve open a bronze seat is formed similar to a valve seat, and prevents leakage through the threads mentioned. This arrangement of seating at the top of the valve stem eliminates the necessity of packing and a stuffing box. The hydrant valve is located in the bottom of the stand-



pipe and has no connection with the hydrant shoe. This feature enables the user to purchase standard hydrants and place them over any depth trench that is desired. Four and one-half to five full turns fully opens the valve. All removable and stationary parts that are threaded into one another are of bronze, so that they do not become rust bound.

Valve Extends Measurement Range of Water Meters

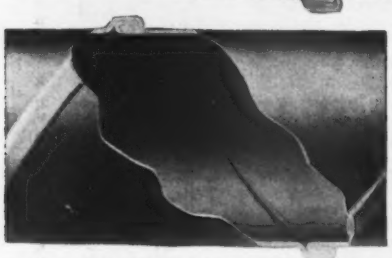
A compounding valve has recently been developed by the Hersey Manufacturing Co., South Boston, Mass., by which water departments can compound existing meters when it is desired to accurately measure a wider range of flow than can be covered by a single meter. As shown in the illustration, the device consists of an automatic



valve and a tee which is bypassed with a meter. Shut-off valves are provided at either end of the meter line. The space-piece in the bypass can be made any length to suit the length required.

Spiral Pipe Uses a Flanged Lock Seam Instead of Rivets

Spiral rivetless pipe is a new product developed by the Naylor Spiral Pipe Co., 1230 E. 92nd St., Chicago. No rivets are used in the pipe, the spiral seams



TOP—PIPE FOR ABRASIVE MATERIALS
BOTTOM—PIPE FOR WATER; AIR; GAS

being formed by interlocking flanges. The machines on which the pipe is formed were designed and patented by Carl G. Naylor, president of the company. A strip of sheet metal is wound into spiral shape, the edges automatically flanged and formed into either a 4- or 5-ply lock-seam laid up on the outside of the pipe. Thus the pipe has a smooth bore and is also claimed to be especially strong and of light weight. The pipe is formed in a continuous piece and then cut in any desired length up to 40 ft. It is made from No. 16 to No. 10 gage sheets and from 4 in. to 30 in. in diameter. Plain, galvanized, painted and asphalted spiral pipe is available to meet varying requirements.

Bell Brace for Tapping Into Large Water Mains

A new product of the McWane Cast Iron Pipe Co., Birmingham, Ala., is a bell-brace unit designed primarily to furnish a flexible bell and spigot joint at points where a corporation cock is tapped into a water main. As shown in the illustration, the corporation cock is screwed into the main, the bell brace is screwed on the opposite end, and the wedge is lightly driven between the

brace and the water main to give the necessary rigidity. A precalked joint in the bell takes a plain end cast iron or wrought iron pipe. The bell brace is claimed to have an advantage over a gooseneck in that the wedge braces the corporation cock which in a gooseneck goes unsupported. The wedge is grooved so that a chisel can chip off any required amount necessary to make it fit.

Efficiency of Steam Turbine Driven Centrifugal Pumps

The De Laval Steam Turbine Co. of Trenton, N. J., submits the accompanying table as showing progressive improvements made in the efficiency of geared turbine-driven centrifugal pumps for water works service during the past five years. The test results submitted are from the official test records of the city of Chicago. All of the units reported upon are of the same size and were designed for the same steam pressure, superheat and water conditions. The increase in duty from the 154,362,000 ft. lbs. per thousand pounds of steam obtained in 1920, to the 191,300,000 ft.-lbs. per thousand pounds of steam obtained in 1925, is claimed to correspond to a saving in steam and fuel of over 19 per cent.

	1920	1923	1925
Steam pressure (lb.)—specifications	175	175	175
Steam pressure—on test	168.04	142.1	176.15
Superheat (deg.)—specifications	150	150	150
Superheat—on test	126.6	123.6	133.4
Capacity (mgd.)—specifications	60	60	60
Capacity (mgd.)—on test	60.0	59.0	60.66
Head (ft.)—specifications	150	150	150
Head—on test	151.51	150.35	152.06
R. P. M—specifications	530	530	530
R. P. M—on test	507	501.5	507.4
Duty (million ft. lbs./1,000 lb. steam) specifications	152	168	179.8
Duty—test curve	154.362	172.0	191.3

Publications from the Construction Industry

Water Meters — REPUBLIC FLOW METERS CO., Chicago, has issued a new bulletin on "The Measurement of Water." The text and illustrations of the booklet are devoted to the subject of metering water by electrical devices.

Electric Equipment—GENERAL ELECTRIC CO., Schenectady, N. Y., has issued its catalog 6,001-B superseding all previous catalogs issued by the company with the exception of those dealing with railway, mine and industrial supplies, and merchandise products. This complete catalog is issued every two years. The catalog is thumb indexed into 16 sections, contains 1,100 pp. and 3,200 illustrations. It covers all of the electrical equipment manufactured by the company, with the exception of that mentioned above.

Roofing—BIRD & SON, INC., East Walpole, Mass., has issued a folder with specifications and samples of its Paroid built-up roof, which consists of layers of asphalt saturated felt, on top of which is a cap sheet for protection from sun and weather. Specifications are given for standard weight and extra heavy weight for their application over sheathing, concrete or tile.

Pumps—BLAKE PUMP & CONDENSER CO, Fitchburg, Mass., in its new booklet "High Efficiency Pumping Machinery" describes its line of heavy duty pumps. Each type is illustrated and described and several pages in the back are devoted to detail illustration of both the power and fluid end of the various pumps.

Motor Trucks—GRAHAM BROS., Detroit, has made available a 67-p. catalog, entitled "Trucks for Public Utilities." Besides describing the many models of trucks available, lists of present users and a good many photographs of their truck fleets are given.

Aluminum Paint—ALUMINUM CO. OF AMERICA, Pittsburgh, Pa., has made available a small paint manual written by two of its research engineers. The text tells how to select, how to prepare, and how to use the proper paint.

Business Side of Construction

FACTS AND EVENTS THAT AFFECT COST AND VOLUME

Water-Works Construction Shows Steady Upward Trend During Past Thirteen Years

Illinois, Pennsylvania and Texas Gain Heavily Over Last Year—Projected Work Most Active in Mid-West and South

THE amount spent per capita for water-works construction in 1925 was three times that for the year 1913, according to *Engineering News-Record* statistics.

The yearly water-works totals of contracts awarded show a straight line trend upward. The accompanying tabulation gives the per capita expenditure for each year from 1913 to 1925 inclusive:

1913	$0.215	1920	$0.208
1914	.225	1921	.355
1915	.217	1922	.334
1916	.241	1923	.566
1917	.273	1924	.549
1918	.122	1925	.611
1919	.188		

The chief gains in water-works construction during the first four months of 1926 over the corresponding period of last year were made in the South, Middle West, Far West, and New England Sections. Some of the outstanding states and the sections of the United States are tabulated for these two periods herewith:

	First 4 Mos. 1926	First 4 Mos. 1925
Massachusetts	$54,000	$505,000
Rhode Island	471,000	306,000
New York	672,000	3,298,000
Pennsylvania	1,258,000	1,031,000
Maryland	415,000	1,079,000
North Carolina	279,000	213,000
Louisiana	44,000	159,000
Ohio	1,201,000	1,938,000
Illinois	1,259,000	1,055,000
Minnesota	263,000	1,155,000
Missouri	1,323,000	9,108,000
Texas	1,214,000	767,000
Washington	289,000	563,000
New England	1,328,000	811,000
Middle Atlantic	2,695,000	5,445,000
Southern	3,187,000	545,000
Middle West	4,935,000	3,905,000
West of Mississippi	7,731,000	11,671,000
Far West	2,960,000	2,147,000
Total for United States	$22,836,000	$24,524,000
Canada	$161,000	$659,000

The proposed water-works construction program for the first third of 1925 is much heavier than that of the present year. The sections that stand out prominently with a consistent proposed work schedule are the South, the Middle West, and the states lying between the Mississippi River and the Rocky Mountains. Canada's heavy 1925 program of proposed work included a duplication of the Toronto water-works system which was estimated at $14,000,000.

Among the contracts awarded for water-works construction during the first three months of the present year are the following: Ft. Worth, Tex., $358,441; Port Arthur, Tex., $252,533; Ft. Smith, Ark., $1,250,000 to $3,000,000; New Haven, Conn., $750,000; Knoxville, Tenn., $955,071; Long Beach, Miss., $944,336; San Diego, Calif., $965,802; Monroe, N. C., $250,000.

The figures for the proposed program of water-works construction is given here by sections:

	1926	1925
New England	$2,093,000	$6,065,000
Middle Atlantic	1,493,000	7,772,000
Southern	6,044,000	4,554,000
Middle West	8,895,000	8,421,000
West of Mississippi	10,932,000	21,844,000
Far West	3,779,000	7,470,000
Total	$33,236,000	$56,126,000
Canada	$2,850,000	$22,035,000

This Week's Special Tabulation of Unit Prices

6. Rock Excavation

Included in the low bidder's estimates on various state highway projects, are the following:

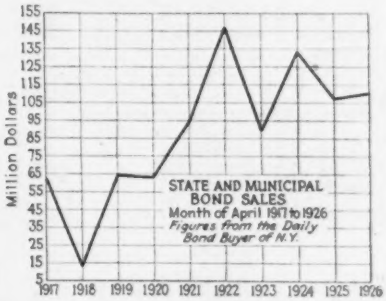
Location	Date	Cu.Yd.	Price per Cu.Yd.
Kentucky, Proj. 29	Aug. 1922	37,548	.85*
Kentucky, Proj. 76	Aug. 1922	39,510	1.05*
Utah	Sept. 1922	700	1.75*
Vermont, Proj. 33	Sept. 1922	200	2.00
Washington	Oct. 1922	135,880	1.10*
Montana	Oct. 1922	19,555	1.00
Kentucky	Sept. 1923	43,262	.80†
Idaho	Nov. 1923	4,428	1.25*
		14,671	.55†
Oregon	Dec. 1923	83,000	1.00
Kentucky	Jan. 1924	1,000	1.50*
		5,000	1.00†
New York	Feb. 1924	2,150	3.00
Idaho	May 1924	10,125	1.35*
		13,707	.50†
Idaho	Apr. 1925	4,265	1.50*
Oregon	Jan. 1926	66,000	.85*
Idaho	Mar. 1926	479	1.50*

* Solid. † Loose.

Borrowings for Municipal Improvements Continue Heavy

State and municipal bond sales for the month of April show a decline from the March, 1926 figure but an increase over the April, 1925 sales, according to the *Commercial and Financial Chronicle*. The total awards for April were $105,696,371, compared with $116,027,179 for March and with $93,671,659 for April a year ago.

The largest single issue placed during April was for $25,000,000 by the city of Philadelphia. This award went at par, $23,000,000 as 4½s and $2,000,000 as 4½s.



Other large placements made during April: $7,500,000 4½s, State of Missouri; $5,000,000 4s, Chicago Sanitary District, Ill.; $3,500,000, Louisville, Ky.; $3,250,000, Lake Worth Inlet District, Fla.; $1,656,000 4½s, Nassau County, N. Y.

In the April disposals rates ranged from 4 to 6 per cent. Several of the issues were at par, a few below, but the greater number commanded a premium.

This Week's Contracts—Week Ago—Same Week Last Year

THE money value of contracts reported in the present issue of *Engineering News-Record* is here compared with the figures for corresponding weeks. Minimum costs observed are: $15,000 for water-works and excavations; $25,000 for other public works; $40,000 for industrial and $150,000 for commercial buildings.

Money Value of Contracts Let—Entire U. S.

Week Ending	Public Work	Private Work	Total Contracts
May 27, 1926	$18,122,000	$40,018,000	$58,140,000
May 20, 1926	32,192,000	37,975,000	70,167,000
May 28, 1925	26,533,000	23,853,000	50,386,000
Heaviest Week			
1926, Mar. 11	13,029,000	73,613,000	86,642,000
1925, Sept. 3	16,215,000	69,424,000	85,639,000
January 1 to date			
1926	400,615,000	720,867,000	1,121,482,000
1925	405,116,000	529,764,000	934,880,000

Weekly Construction Market

PRICES of the fourteen materials in nine important cities listed below, show an excess of advances over declines, compared with a month ago. Rivets are up 25c. per 100 lb. in Seattle; steel pipe discounts are lower in Atlanta and San Francisco warehouses; c.-i. pipe advanced $1 per ton in New York and dropped $1 in Atlanta; lumber is off 50c. at New York and up $1 to $1.50 per M.ft. in Minneapolis; lime declined 40c. per bbl. in Dallas and rose 25 to 35c. in Minneapolis; brick is down $1 per M. in Dallas and tile, 1c. per block at Seattle; the rise in linseed oil amounts to 0.7c. in Atlanta, 1c. in San Francisco and 2c. at Chicago, while a drop of 2c. occurred in Denver and the New York market is off 2½c., compared with last month. Montreal shows sharp gains in steel shapes, reinforcing bars, and aggregates. The marked stability of cement prices throughout the United States, however, is in contrast with reported price cutting in Canadian cement, amounting, it is said, to as much as 60c. per bbl. in thirty days. Comparing prices of the same materials in the same cities with those in effect one year ago, it is found that the declines are in excess of the advances. The thirty-four declines and the twenty-six advances were so evenly distributed throughout the country that the only materials showing definitely higher levels than a year ago are, steel pipe, cast-iron pipe, lumber and lime. Steel shapes, reinforcing bars and linseed oil are lower than during the last week in May, 1925. Cement shows an advance of 5c. per bbl. in Atlanta, compared with a year ago and a decline of 10c. in Chicago and Minneapolis, while the Montreal market is down 38c. per bbl.

	New York	Atlanta	Dallas	Chicago	Minneapolis	Denver	San Francisco	Seattle	Montreal
Steel Products									
Structural shapes, 100 lb.	$3.34	$3.40	$4.15	$3.10	$3.35	$3.07½	$3.30	3.35	$4.00
Structural rivets, 100 lb.	4.50	3.50	4.75	3.50	3.75	4.65	5.00	4.00	5.50
Reinforcing bars, ¾ in. up, 100 lb.	3.24	3.30	3.38	3.00	3.25	3.77½	3.20	3.25	3.25
Steel pipe, black, 2½ to 6 in. lap, discount	48%	35.5%	53.6%	55%	54.25%	36%	35.6@49.2%	45%	59.49
Cast-iron pipe, 6 in. and over, ton	51.60@53.60	45.25	54.00	49.20@50.20	53.00	64.00	52.00	55.00	55.00
Concreting Material									
Cement without bags, bbl.	2.50@2.60	2.35	2.05	2.10	2.32	2.85	2.31	2.65	1.42
Gravel, ¾ in., cu.yd.	1.75	1.90	2.38	1.60	1.65	1.90	1.80	1.50	1.50
Sand, cu.yd.	1.00	1.60	2.00	1.40	1.25	1.00	1.40	1.50	1.25
Crushed stone, ¾ in., cu.yd.	1.85	2.50	2.83	1.87½	1.75	2.50	1.70	3.00	1.70
Miscellaneous									
Pine, 3x12 to 12x12, 20 ft. and under, M.ft.	62.00	34.00	56.00	41.00	+39.00@39.75	34.75	—25.00	25.00	55.00
Lime, finishing, hydrated, ton	18.20	23.50	20.00	20.00	25.00	24.00	22.00	24.00	21.00
Lime, common, lump, per bbl.	2.25@2.75	1.50	1.85	2.25	1.60@1.70	2.70	1.60	2.80	10.00
Common brick, delivered, 1,000	20.40	10.50	11.10	12.00	14.25	12.00	15.00	15.00	17.50
Hollow building tile, 4x12x12, per block	Not used	.0895	.10	.075	.076	.075	.....	.09	.12
Hollow partition tile 4x12x12, per block	.1112	.0895	.10	.075	.076	.075	.108	.09	.10
Linseed oil, raw, 5 bbl. lots, gal.	.84	.91½	1.13	.87	.95¼	1.04	.97	1.12	1.10
Common Labor									
Common labor, union, hour	.62½@.75	.30	.....	.87½	.....	.50@.55	.55	.62½	.....
Common labor, non-union, hour	.....	.25	.30@.50	.82½	.45@.55	.35@.50	.50	.50	+.30@.35

Explanation of Prices—Prices are to contractors in carload lots unless other quantities are specified. Increases or decreases from previous quotations are indicated by + or — signs. For steel pipe, the prevailing discount from list price is given; 45-5% means a discount of 45 and 5 per cent.

New York quotations delivered, except sand, gravel and crushed stone, alongside dock; common lump lime in 280-lb. bbl. net and hydrated lime, f.o.b. cars; tile "on trucks"; linseed oil and cast-iron pipe f.o.b. Labor—Concrete laborers' rate, 93¾c.; building laborers, 75c.; excavating laborers, 62½c. per hr.

Chicago quotes hydrated lime in 50-lb. bags; common lump lime per 180-lb. net. Lumber, sand, gravel and stone f.o.b.; price on fir is quoted instead of pine.

Minneapolis quotes on fir instead of pine. Brick, sand and hollow tile delivered. Cement on cars. Gravel and crushed stone quoted at pit. Common labor not organized.

THIS limited price list is published weekly for the purpose of giving current prices on the principal construction materials, and of noting important price changes on the less important materials. Moreover, only the chief cities are quoted.

Valuable suggestions on costs of work can be had by noting actual biddings as reported in our Construction News section.

The first issue of each month carries complete quotations for all construction materials and for the important cities. The last complete list will be found in the issue of May 6, the next on June 3.

Denver quotes on fir instead of pine. Cement "on tracks"; gravel and sand at pit; stone on cars; lime, brick, hollow tile and lumber on job. Tile price is at warehouse. Linseed oil, delivered in wooden bbl. Common lump lime per 180-lb. net.

Atlanta quotes sand, stone and gravel per ton instead of cu.yd. Common lump lime per 180-lb. net.

Dallas quotes lime per 180-lb. bbl. Steel, cement, cast-iron pipe and crushed stone f.o.b. cars, other materials delivered.

San Francisco quotes on Heath tile, size 5½ x 8 x 11½. Prices are all f.o.b. warehouses except C.-I. pipe, which is mill price plus freight to railway depot at any terminal. Common lump lime per 180-lb. net. Lumber prices are to dealers in yards at San Francisco, for No. 1 fir, common.

Seattle quotes on Douglas fir (delivered) instead of pine. Lump finishing lime per 180-lb. net. Brick and hollow building tile delivered. Hydrated lime in paper sacks. Sand and gravel at bunkers.

Montreal quotes on fir lumber. Sand, stone, gravel and lump lime per ton. Stone and tile are delivered; sand, gravel, lime and cement on siding; brick f.o.b. plant; steel and pipe at warehouse. Hollow tile per ft. Cement price is in Canadian funds (the Canadian dollar stands at 100.031). Bag charge is 80c. per bbl. Discount of 10c. per bbl. for payment within 20 days from date of shipment. Steel pipe per 100 ft. net; 3½-in., $59.49.

Business Briefs

Call money quoted at 3¾@4½ per cent, May 21; year ago, 4 per cent.

Time loans: sixty-ninety days, 4; four-six months, 4@4½ per cent.

Commercial paper: best names, 4 per cent; other names, 4½ per cent.

On May 1, 1926

E. N.-R. Construction Cost Index Number 207.30

E. N.-R. Construction Volume Index Number 233

For Explanation and Details of Indexes Since 1913 See the First Issue of Every Month